CRUISE REPORT

RV Poseidon Cruise 325

Bremerhaven – Tromsø

Leg 1: Bremerhaven – Tromsø, 12 July – 24 July 2005

Leg 2: Tromsø – Tromsø, 24 July – 3 August 2005

12 July – 3 August 2005

André Freiwald, Wolf-Christian Dullo

and Shipboard Party

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1. Scientific Objectives

This cruise is part of the 6th Framework Programme of the European Commission, the HERMES Integrated Project (Contract GOCE-CT-2005-511234 and see www.eu-hermes.net for further information) and is associated to Workpackage 2 "Coral Reef and Carbonate Mound Systems" led by André Freiwald (P.I. of P325). The general aim of this workpackage is

- to understand the structure, functioning and dynamics of cold-water coral ecosystems under different trophic regimes and under different climatic settings.
- to investigate the change of biodiversity which affected cold-water coral ecosystems during the last glacial-interglacial cycle and to forecast what way the ecosystem will react to future environmental change.
- to study the links between deep-water circulation patterns and the likely geosphere-biosphere coupling of cold-water coral ecosystems in hydrocarbon provinces.
- to analyse and minimise the negative impacts of human activities on cold-water coral ecosystems through provision of mitigation options, risk assessments and recommendations for management and conservation.

Cruise Objectives

This cruise was dedicated to re-visit some of the northernmost coral reef complexes (Fig. 1). Of particular interest were build-ups in the Trænadjupet, the Røst Reef and in the Stjernsund. The first two locations were discovered through dedicated seabed mapping surveys under the auspice of the IMR and Norwegian Geological Survey, whereas the Stjernsund site belongs to one of the famous Carl Dons locations. In addition, sites on the Sveinsgrunnen, Fugløybanken Trough and Sotbakken were searched for benthic communities as well. The objectives were:

- to map the reef architecture and geometry using a multibeam system.
- to measure physical watermass properties with CTD and water sampler.
- to document the sedimentary facies and biological habitats within and adjacent to reef complexes.
- to identify the species composition and their abundancies and functional role within the coral ecosystem.

- to analyse the postglacial geological evolution of coral reefs by obtaining long sediment cores.

All these scientific results will be compared with existing information about cold-water coral ecosystems along the entire European and Mediterranean ocean margin.

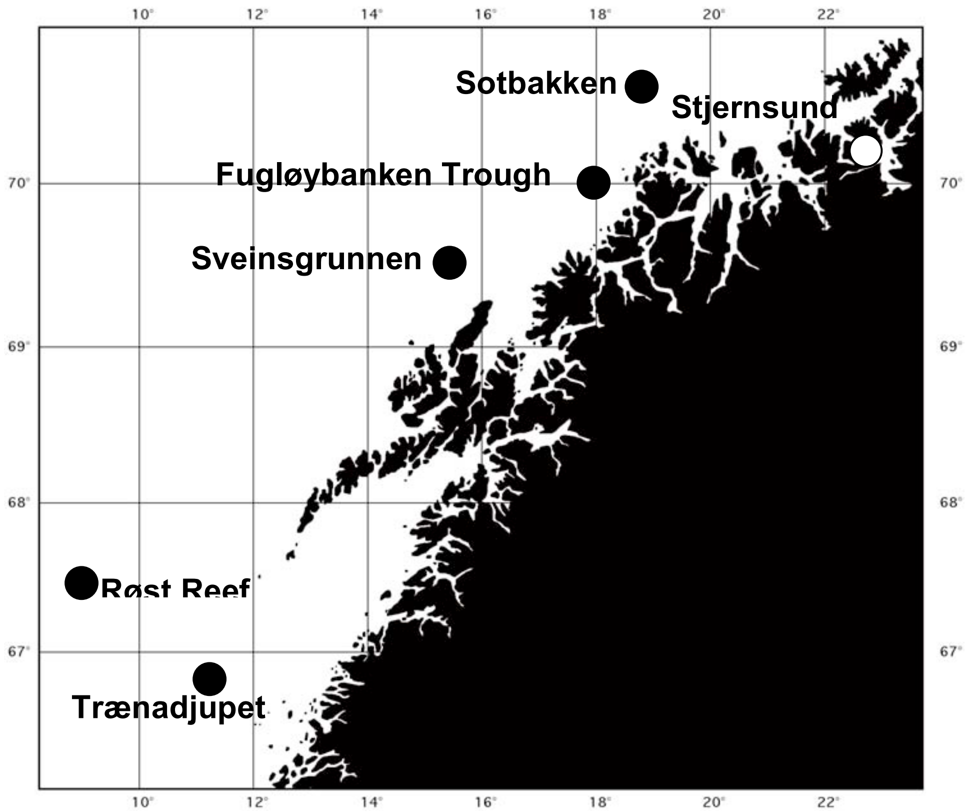

Fig. 1. Geographic map showing all study sites of the P325 cruise off northern Norway.

2. Narrative Cruise Report

This narrative report covers the period 12 July to 2 August 2005. In the following narrative report, the daily scientific activities of P325 logged consecutively with station numbers are noted in brackets. The complete station list is annexed at the end of the cruise report.

12. July (Tuesday)
We left the Labradorhabour, Bremerhaven, at 08:08h. A transit to Helgoland was used for engine trials and calibration of the newly installed multibeam system. In the evening, all service technicians were disembarked with the kind assistance of the BAH/AWI. Since 18:30h we are heading north.

13. July (Wednesday)
Today we passed the Skagerrak and reached the southwestern Norwegian Shelf at Egernsund Bank. Preparation of equipment and calibration works continued. Weather conditions calm but increasing northerly winds in the afternoon.

14. July (Thursday)
We passed Bergen today under a moderate wind with occasional rain showers from stern pushing us nicely towards our first working area. The day was used to check the box-corer for functionality, to mobilise the submersible on the working deck and to prepare protocol log sheets.

15. July (Friday)
Perfect weather conditions during the last transit day enabled us to run a submersible deployment-recovery manoeuvre so that the crew became familiar with the handling. In the evening, an overview briefing on the research themes of this cruise was offered to the crew.

16. July (Saturday)
We have crossed the Polar Circle early in the morning and reached the northern slope of the Trænadjupet at 7:30h. The scientific programme started with a CTD Station **(#338)** to gain information on watermass stratification and for the sound-

velocity calibration of the multibeam system. A trial-multibeam (MB) profile started with a slight delay because of a software failure **(#339)**. A MB grid over a coral reef area was mapped until noon **(#340)**. The first JAGO dive **(#341)** revealed that all the about 100 to 150 m long and up to 4 m thick structures represent dead coral reef mounds with sparse living coral growth preferably in up-current (eastern ends of the elongated reef mounds) positions. The evening until midnight was open for a first Van Veen grab sampling party **(#342 - 353)**. The recovered samples represent all facies types that were visually inspected during the JAGO dive. Shortly after midnight, we finished our daily programme. The sea was flat and no winds.

17. July (Sunday)

A CTD station **(#354)** started with the new day followed by another MB mapping grid due west of the already existing dataset obtained yesterday **(#355).** After breakfast, another sunny and calm day invited us for the second submersible dive **(#356)** across another set of elongated reef mounds. More live corals were found here compared to the eastern reef chain. The afternoon was reserved for heavy metal works. Two box-corers were precisely placed on the reef tops **(#357** and **#358)** followed by a gravity-corer with a 6-m-barrel **(#359)**. This corer penetrated the entire coral mound and stuck into the probably Late Pleistocene stiff clays underneath. The afternoon programme continued with a CTD station near the largest live coral occurrence found during the today's JAGO dive **(#360)**. The mapping team finished the last MB line and prepared the maps **(#361)**. After dinner, we left this part of the inner Trænadjupet and headed west towards the outer Trænadjupet were a CTD was launched in the deepest part of the deep shelf trough **(#362)**. We, scientists and crew, were satisfied with the results and weather conditions of the day.

18. July (Monday)

We arrived in the northernmost area of the Røst Reef in the morning. Because the weather was good, we decided for a quick reconnaissance dive across the slope from 350 m water depth upslope **(#363)**. We reached a seabed accentuated by compressed stiff clays and gravelly to bouldery lag deposits. The larger pebbles and boulders were densely colonised by a diverse sponge community. During the battery-recharge time of JAGO, we mapped a small grid on the outermost shelf rich in iceberg ploughmarks **(#364)**. In the afternoon, we had the second JAGO dive of the day in quite shallow waters on the shelf **(#365)** and documented an extremely rich brachiopod and ophiuroid community covering the seabed. We dove along the levees of an iceberg ploughmark and found alcyonarians always forming dense accumulations in up-current situations. The night programme was scheduled to map substantial parts of the upper slide area with multibeam **(#366)** to prepare promising dive sites to inspect coral reefs tomorrow. The sea is calm and the midnight sun is shining.

19. July (Tuesday)

After breakfast the MB map was printed and showed the expected sediment pressure ridges of the Trænedjupet slide which should be the home of cold-water coral reefs. Unfortunately, the wind and sea picked up so that the scheduled JAGO dives of the day had to be abandoned. Instead, we inspected the dive sites with Van-Veen grabs **(#367-372)** and were always successful in finding either coral rubble or live corals (both *Lophelia* and *Madrepora*). A detailed CTD-transect that encircled a particular pressure ridge started in the afternoon. However, a gale with force 8 led to an end of the CTD transect in the evening **(#373-381)**.

20. July (Wednesday)

Full force 10 gale from northerly directions today and we decided to head towards Sveinsgrunnen to keep an option for investigating cold-water corals there, or to hide in the Malangen Fjord, if the gale will blow longer.

21. July (Thursday)

Still on the way to Sveinsgrunnen. Swell and sea is going high under force 7-8 winds but steadily decreasing during the day. In the night, we reached the western spur of Sveinsgrunnen and started with an echosounder profile to gain information about the steepness of the slope **(#382)**. At 1000 m depth, a CTD **(#383)** profile was taken and has reached the upper limit of the Arctic Intermediate Water with temperatures of -0.6°C at 600 m water depth.

22. July (Friday)

Work on Sveinsgrunnen continued with a second echosunder line **(#384)** further east. The slope surveyed is very steeply inclined. Until the morning, the area between the two echosunder lines was multibeam-mapped **(#385)**, followed by a shallow-water CTD **(#386)** at 185 m depth. A set of Van-Veen grabs revealed boulders and stiff clays which are colonised by sponges, tunicates and many carbonate-secreting organisms (bryozoans, serpulids, brachiopods, bivalves) **(#387-392)**. We decided to abandon a scheduled JAGO dive here and finished the programme with 3 CTD stations over the slope area **(#393-395)**. In the evening, we sailed to a small trough off Rebbenesøy. This east-west oriented trough, which is incised between the Malangsgrunnen and the Fugløybanken, is structured with a sill in the central part. A first CTD **(#396)** was taken for sound calibration of the multibeam system.

23. July (Saturday)

The entire night was used to produce a MB map **(#397)**. Indeed, two prominent structures became visible on the sill in the trough off Rebbenesøy. These structures were investigated with the Van-Veen Grab **(#398-408)**. The sill is covered with boulders and lag-deposits, the deeper basin sediments consist of clayey to silty sands, while from the northern slope of Malangsgrunnen, calcareous sands made up of bryozoans and molluscs were imported. In the afternoon, we continued MB mapping **(#409)** in this area, however, the wind picks up to gale force again. After this exercise we steamed along the coast towards Hekkingen and approached Tromsø through the Malangen Fjord to finish Leg 1 of P325.

24. July (Sunday)

A film team documented our docking in the central part of the city of Tromsø. Dizzling showers and exchange of scientists characterised the day. We left Tromsø for Leg 2 at 18:00h through the scenic Lyngen Fjord, passed Fugløy and headed towards the Stjernsund, our next major working area.

25. July (Monday)

At 04h, a CTD station **(#410)** opened the scientific session in the Stjernsund followed by a first MB mapping over a pronounced sill area **(#411)**. The sill is thought to represent an end moraine most likely of Younger Dryas age. The first JAGO dive **(#412)** was launched over the central eastern flank and encountered strong tidal bottom currents coming from the west (Atlantic side). We sampled live white and red

Lophelia that forms cauliflower-like patch reefs. The widespread coral rubble facies is colonised by alcyonarians (*Capnella/Drifa*) and *Tubularia*. Towards the upper mid slope, tidal currents picked up so that we surfaced. Four grabs following the previous dive track were taken from the seabed **(#413-416)**, yielding an excellent overview of the small background fauna. In the afternoon, a second JAGO dive led to the upper western slope of the sill **(#417)**. However, the tidal current was still vigorous so that the sub encountered great difficulties to keep the station work. In the evening, a detailed CTD and water sampling transect crossing the Stjernsund sill from east to west was carried out successfully **(#418-424)**.

26. July (Tuesday)

Early in the morning, we completed the MB map from the Stjernsund **(#425)**. Later on, three grabs were taken from the top and the up-current slope of the sill **(#426-428)**. With the sinking tide, we launched a very successful JAGO dive crossing several facies including a mature coral reef **(#429)**. In the afternoon we sampled the western Stjernsund Trough with the box-corer **(#430-1, -2)** and a 6 m long gravity-corer **(#430-3)** successfully. In the evening, we steamed towards the southern part of the Nord-Vest Bank, named Søtbakken.

27. July (Wednesday)

At the Søtbakken slope a CTD for sound velocity profile of the MB was measured **(#431)**, followed by a MB mapping until the early morning **(#432)**. At 04h, we steamed back to the Stjernsund in order to reach the sinking tide period in time. We arranged a helicopter picking up for the TV-team and launched JAGO at the steep up-current slope of the sill **(#433)**. The sharp upper slope edge is covered by a dense coral reef structure. In the afternoon, we tried to core the eastern trough with the box-corer **(#434-1)** and the gravity-corer **(#434-2)**. The box-corer had technical problems and the gravity-corer did not penetrate deep into the rubber mat-like deposits. In the evening, a long CTD transect **(#435-455)** was launched to cover the change of physical mass properties over a full tidal cycle.

28. July (Thursday)

The CTD profiling ends in the morning, followed by two box-corer stations **(#455-456)** on the eastern slope of the Stjernsund sill with moderate recovery of coral rubble sediments. Then, one 3 m long and two 6 m long gravity-corers were taken **(#457-459)**. In the afternoon, the big reef was visited again with JAGO **(#460)**. In the evening, we steamed back to Sotbakken. The weather was cold and rainy all the day.

29. July (Friday)

The night was spent with mapping in the Sotbakken area **(#461)**. Promising sites were sampled with the Van-Veen grab **(#462-467)**. The most promising target was visited with JAGO **(#468)**. We found alignments of ice-rafted boulders which were released from melting icebergs during their drift and spotted boulder-rich ridges possibly representing moraines. These boulder-rich areas are densely covered with sponges, hydrozoans and bryozoans. In the evening, we filled the last gaps in the MB map **(#469)** and left the area late in the night. Weather was fine but a swell exists during the day.

30. July (Saturday)

We came back to the Stjernsund early in the morning and started a gravity-corer transect crossing the sill from NW to SE **(#470-473)**. Although it lushes rain, the motivation and the core recovery was excellent. In the afternoon, we launched another JAGO dive over the southern part of the Stjernsund sill and found more reefs **(#474)**. The evening was dedicated to our last CTD transect to catch tidal variability on physical watermass properties along the sill crest **(#475-480)**.

31. July (Sunday)

The last MB mapping covered the entire basin SE of the Stjernsund sill **(#481)** for finding a deep microbasin for coring. The wind picked up to 30 knots and we had a swell even inside the Stjernsund. The coring business went well. We carried out a box-corer and a gravity-corer station **(#482-1, -2)** and a last gravity-corer station near the foot of the western slope of the Stjernsund sill **(#483)**. In the afternoon, the southern reef ridge of the sill was inspected with JAGO in great detail **(#484)**. The day ended with a video presentation for scientists and crew to demonstrate first results. The weather was rainy and cold.

01. August (Monday)

The weather was unpleasant as the day before. We started with clearing up the labs, finalising protocols for the cruise report and launched JAGO two times **(#485-486)**. End of scientific work in the early evening. We celebrated the success of the cruise with a joint barbeque.

02. August (Tuesday)

Loading, packing, cleaning and reporting filled the entire day. We left the Stjernsund (Fig. 2) in the evening and steamed back to the final port call in Tromsø.

Fig. 2. RV POSEIDON in the Stjernsund.

3. Technical Report

Research Submersible JAGO

Jürgen Schauer, Karen Hissmann

"JAGO" is a manned submersible devoted primarily to research in the marine sciences. It allows researchers a personal view of the seafloor with the greatest degree of freedom. The underwater craft is certified to a maximum operating depth of 400 m and was designed and built according to the rules for classification and construction of the Germanischer Lloyd (Tab. 1). The highly manoeuvrable vehicle can accommodate two persons, the pilot and a scientist/observer, at atmospheric pressure/environment.

JAGO has two large acrylic dome ports that allow excellent visibility on the seafloor (Fig. 3). The craft is electrically driven and able to move underwater autonomously within the reach of the navigation and communication systems of the surface vessel.

Table 1. General specifications of JAGO

Length: 3.2 m **Beam:** 2.0 m **Height:** 2.5 m **Weight:** 3033 kg **Draft:** 1.6 m
Displacement: 3200 litre **Operating depth:** 400 m **Crew:** 2 persons
Pressure hull: Thickness of cylinder 15 mm, half-spheres 18 mm, TST E 355-HII-1.45.71 steel
Viewports: Material acrylic plastic, 50-80 mm thick, diameter of front bow-window 70 cm, hatch-window 45 cm
Propulsion: 4 reversible stern-thrusters (horizontal), 2 side-thrusters (360° rotable)
Cruising speed: approx. 1 knot
Energy supply: 3 battery sets, capacity: 540 Ah - 24 Volt DC
Manipulator: hydraulic, 8 functions and exchangeable claws, max. lift capacity approx. 5 kg
Navigation: LXT underwater tracking system, fluxgate-compass, D-GPS satellite-navigator, vertical and horizontal sonar, depth gauges, pinger positioning
Communication: underwater telephone (ORCATRON, 10 & 27 kHz, range approx. 8 km), VHF-radio
Emergency systems: "Dead Man" controlled ballast release system, manual ballast release, positive buoyancy capacity of min. 600 kg in maximum diving depth, emergency buoy with rescue installation, life support 96 hours (2 persons)
Other equipment: 5 halogen-projectors, 2 flash-lights, water-, gas-, plankton-, and sediment sampling, physical instruments and sensors; digital video-, und still cameras for documentation; VEMCO-ultrasonic-transmitter receiver

The vehicle is equipped with fluxgate compass, USBL-navigation and tracking system, underwater telephone, sonar, video and still cameras, oceanographic sensors and 8-function manipulator arm for handling various sampling devices to accomplish almost any underwater work from within the sub. Typical applications are benthic and/or mid-water observations and surveys, video/photo documentation, underwater sampling, environmental studies, search and location of objects, salvage work and support in emergency cases.

Because of its compact construction and small weight of 3 tons, JAGO can be launched and recovered from nearly any larger boat and vessel with sufficient crane capacity. Overseas transportation is made with a shippers own 20' standard sea freight container.

JAGO was built in 1989, and is maintained and operated by a small expert team (Hans Fricke, Jürgen Schauer, Karen Hissmann). For the last 16 years the craft was stationed at the Max-Planck-Institute for Behavioural Physiology in Seewiesen (Bavaria) and from 2006 on it will be located at the Leibniz Institute for Marine Sciences IFM-GEOMAR in Kiel.

JAGO has made more than 900 dives throughout the World's Oceans and in deep lakes, at hot vents in cold waters off Iceland and New Zealand, in tropical seas off Indonesia, the Caribbean and in the Indian Ocean. It was used to explore seamounts

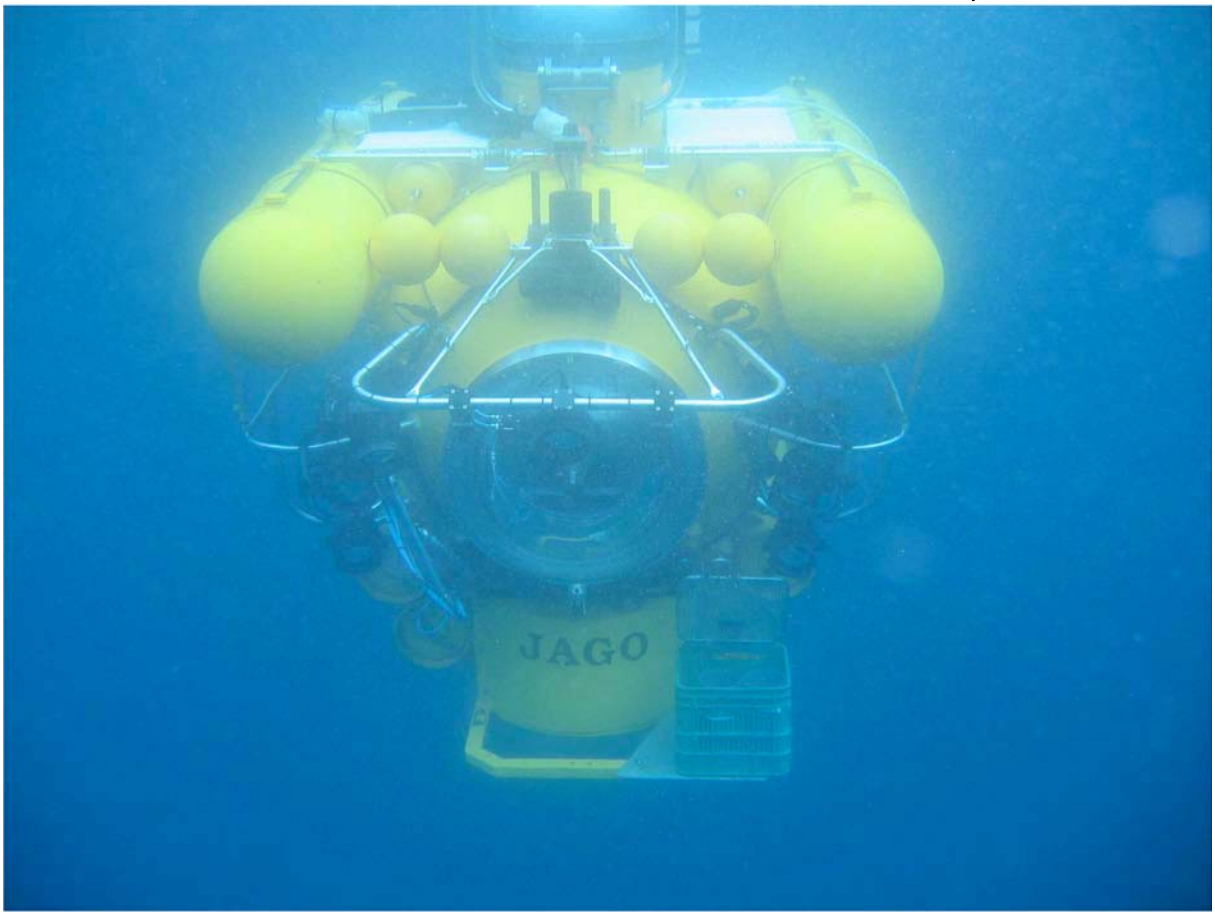

Fig. 3. Research submersible JAGO on the way to the Stjernsund reefs (Photo by Tim Beck).

in the Western Pacific, submarine canyons off South Africa and descended to the anaerobic realms of the Black Sea. JAGO has been used by some hundred different observers, mainly scientists of various disciplines in the field of marine biology, microbiology, geology, palaeontology, sedimentology, biogeochemistry, oceanography, environmental conservation, by film teams, photographers and marine engineers.

Most suitable for deployment and recovery of the submersible are support vessels with a low working deck like the 60 m long RV POSEIDON that has a free board of less than 2 metres and a main deck crane of 6 tons SWL. In the past years, JAGO has been regularly operated from on board the vessel (POS228/229 Norway/Iceland in 1997, POS 253/254 Iceland/Norway in 1999, POS 317 Black Sea in 2004). The POSEIDON is the most suitable support vessel for JAGO within the German fleet of research vessels.

During POS 325 JAGO was used for ground truthing of the multibeam maps, which were produced during the cruise, visual and video documentation of the cold-water coral reefs, and for selective sampling of corals and their associated fauna with minimum impact on the fragile ecosystem. In total, 45 hours were spent underwater on 13 project dives and one trial dive (see Table 2). Five different scientists had the chance for a personal view on the seafloor. Twenty-five hours of video and dive tracks (Lat./Long. positions) for each dive plotted on the multibeam charts are available. Handling of the submersible from on board the POSEIDON went extremely smooth up to wind speeds of 25 knots thanks to the Captain, Michael Schneider, bosun and crane operator Frank Schrader and his deck team, the work boat team Ralf Müller and his assistant, and the skilful hookmen Tim Beck, Sascha Flögel and Andres Rüggeberg.

Table 2. Overviewof JAGO operations during P325 cruise.

P325 Station #	JAGO Dive #	Date	Location	Time submerged	Time surfacing	Total dive time (min)	Touch down position	Lift off position	Min-Max Depth (m)	Pilot	Observer
341	901	16.07.05	Traenadjupet	11:43	15:03	200	N 66.58.091 E 11.07.109	N 66.58.198 E 11.07.415	318-319	J. Schauer	A. Freiwald
356	902	17.07.05	Traenadjupet	6:50	10:46	236	N 66.58.400 E 11.06.529	N 66.58.245 E 11.06.448	297-308	J. Schauer	Ch. Dullo
363	903	18.07.05	Rost Reef	7:23	8:55	92	N 67.34.629 E 09.34.025	N 67.34.621 E 09.35.340	330-356	J. Schauer	A. Freiwald
365	904	18.07.05	Rost Reef	13:22	16:33	191	N 67.34.378 E 09.40.124	N 67.34.179 E 09.40.383	245-253	J. Schauer	A. Freiwald
412	905	25.07.05	Stjernsund	8:18	11:08	110	N 70.15.721 E 22.29.143	N 70.15.954 E 22.24.590	250-275	J. Schauer	A. Freiwald
417	906	25.07.05	Stjernsund	14:10	16:20	130	N 70.16.196 E 22.28.996	N 70.15.344 E 22.30.507	227-358	J. Schauer	Tim Beck
429	907	26.07.05	Stjernsund	8:09	13:21	312	N 70.15.900 E 22.28.609	- -	206-257	J. Schauer	Tim Beck
433	908	27.07.05	Stjernsund	10:15	13:55	220	N 70.16.038 E 22.27.367	N 70.15.425 E 22.29.138	220-344	J. Schauer	Ch. Dullo
460	909	28.07.05	Stjernsund	10:53	14:51	238	N 70.16.032 E 22.27.589	N 70.15.717 E 22.27.119	220-337	J. Schauer	A. Freiwald
468	910	29.07.05	Sotbakken	13:03	16:10	173	N 70.37.410 E 20.07.396	- -	250-300	J. Schauer	A. Freiwald
474	911	30.07.05	Stjernsund	12:07	16:20	253	N 70.15.836 E 22.27.323	- -	223-338	J. Schauer	P. Mortensen
484	912	31.07.05	Stjernsund	12:14	16:58	284	N 70.15.910 E 22.27.480	N 70.15.662 E 22.27.723	206-330	J. Schauer	K. Hissmann
485	913	01.08.05	Stjernsund	8:30	9:57	87	N 70.13.514 E 22.48.671	N 70.13.420 E 22.48.559	100	J. Schauer	R. Dinges
486	914	01.08.05	Stjernsund	12:46	15:37	171	N 70.16.165 E 22.28.246	N 70.16.269 E 22.28.295	276-295	J. Schauer	A. Rüggeberg
Total	**14 dives**					**2697 (45 h)**			**206-358**		

Multibeam Mapping System

Sascha Flögel, Anneleen Foubert

In order to produce detailed bathymetric maps of the seabed to be analysed especially for targeted sampling of small features such as specific sedimentary environments, topographic peculiarities and to map the extension and geometry of cold-water coral occurrences, we used a 50 kHz Seabeam 1180 swath system with 126 beams with 3x3° beam angle. The system was installed in the moon pool of RV POSEIDON together with an OCTANS 3000 motion sensor and a sound velocity probe. Sound velocity profiles of the water column were taken from CTD casts. Cruising speed was between 3 and 7 knots. The data were recorded with the HYDROSTAR ONLINE software from ELAC-Nautik and edited by HDP_Edit. DTMs were processed by HDP_Ppost and grids of different grid space (3-8 m) were exported as latitude-longitude-depth data in ASCII format. For map visualisation we used GMT with WGS84 as reference ellipsoid and Mercator projection. A coordinate list of all multibeam tracks is given in Table 3. During P325, a total of 671 km tracklines were recorded.

Table 3. Overview of all multibeam tracks on P325.

Station	Area	Date	Time	Coordinates		Depth	Remarks	Distance
#			(UTC)	Lat. (°N)	Long. (°E)	(m)		(m)
339	Traena-	16.07.2005	7:54	66°53.17	11°07.16	328	line start	
	djupet		8:07	66°54.19	11°08.90	379	line end	1200
340-1			8:40	66°58.50	11°07.84	309	start	
			8:51	66°58.09	11°05.37	299	end	887
340-2			9:14	66°58.02	11°05.42	301	start	
			9:26	66°58.43	11°07.92	315	end	887
340-3			9:29	66°58.36	11°07.98	318	start	
			9:41	66°57.96	11°05.49	302	end	1425
340-4			9:45	66°57.89	11°05.57	301	start	
			9:57	66°58.29	11°08.06	323	end	1737
340-5			10:01	66°58.21	11°08.14	301	start	
			10:14	66°57.81	11°05.65	301	end	1737
340-6			10:17	66°57.74	11°05.73	300	start	
			10:28	66°58.14	11°08.22	300	end	1737
340-7			10:31	66°58.07	11°08.29	325	start	
			10:42	66°57.66	11°05.81	302	end	1737
355-1		17.07.2005	0:29	66°57.58	11°05.95	327	start	
			0:54	66°56.68	11°00.63	327	end	2484
355-2			0:58	66°56.80	11°00.49	326	start	
			1:23	66°57.69	11°05.86	301	end	2484

355-3			1:27	66°57.82	11°05.71	301	start	
			1:52	66°56.93	11°00.31	320	end	2484
355-4			1:56	66°57.06	11°00.17	320	start	
			2:29	66°57.93	11°05.61	320	end	2219
355-5			2:35	66°58.05	11°05.48	298	start	
			2:49	66°57.18	11°00.01	308	end	2483
355-6			2:52	66°57.29	10°59.88	309	start	
			3:18	66°58.13	11°05.39	295	end	20445
355-7			3:30	66°58.63	11°07.73	290	start	
			4:17	66°57.41	10°59.73	302	end	21332
355-8			4:23	66°57.53	10°59.59	299	start	
			5:01	66°58.74	11°07.68	287	end	21332
355-9			5:18	66°57.85	11°08.76	333	start	
			6:01	66°56.54	11°00.81	320	end	3723
361			15:50	66°56.37	11°01.02	324	start	
			16:28	66°56.71	11°09.05	352	end	3553
364-1	Røst Reef	18.07.2005	10:47	67°35.17	09°36.05	321	start	
			11:33	67°33.16	09°45.50	221	end	4468
364-2			11:40	67°33.01	09°44.81	220	start	
			12:24	67°35.07	09°35.40	368	end	4468
364-3			12:32	67°34.88	09°34.73	340	start	
			12:43	67°34.41	09°36.97	261	end	860
366-1			17:58	67°34.89	09°34.99	345	start	
			19:35	67°29.15	09°21.31	361	end	7901
366-2			19:58	67°29.01	09°21.97	309	start	
			23:09	67°36.65	09°40.05	307	end	11305
366-3			23:20	67°36.88	09°38.99	359	start	
		19.07.2005	1:21	67°29.30	09°20.65	461	end	10998
366-4			1:37	67°29.57	09°19.94	459	start	
			3:28	67°37.18	09°38.11	393	end	12101
366-5			3:50	67°36.40	09°40.78	283	start	
			5:46	67°28.77	09°23.62	280	end	11539
382	Sveins-	21.07.2005	21:51	69°41.41	16°09.97	198	start	
	grunnen		22:03	69°42.52	16°08.99	561	end	1183
384		22.07.2005	0:09	69°43.33	16°20.52	548	start	
			0:26	69°42.25	16°22.19	80	end	1364
385-1			1:05	69°42.25	16°22.18	86	start	
			1:55	69°41.25	16°10.01	200	end	4841
385-2			2:03	69°41.54	16°09.74	186	start	
			2:53	69°42.50	16°21.87	274	end	4841
385-3			3:02	69°42.78	16°21.51	413	start	
			3:41	69°41.84	16°09.47	219	end	4841
385-4			3:52	69°42.12	16°09.18	327	start	
			4:44	69°43.07	16°21.07	499	end	4839
385-5			4:53	69°43.33	16°20.68	556	start	
			5:32	69°42.41	16°08.87	577	end	4839
385-6			6:05	69°41.96	16°16.89	148	start	
			6:28	69°42.37	16°22.13	166	end	2606
385-7			6:35	69°42.63	16°21.69	348	start	
			6:55	69°42.18	16°15.79	158	end	2355
397-1	Fugløy-		21:02	70°08.24	17°53.09	282	start	

	banken		21:53	70°07.16	18°07.07	369	end	20577
397-2			21:59	70°07.39	18°07.22	365	start	
			22:47	70°08.48	17°53.15	291	end	20577
397-3			22:52	70°08.74	17°53.39	328	start	
			23:37	70°07.69	18°07.37	374	end	20577
397-4			23:43	70°07.97	18°07.46	368	start	
		23.07.2005	0:15	70°09.97	17°53.46	343	end	20662
397-5			1:10	70°09.27	17°53.63	329	start	
			2:01	70°08.27	18°07.34	355	end	20567
397-6			2:23	70°06.93	18°06.95	344	start	
			3:08	70°08.00	17°53.06	252	end	20294
397-7			3:26	70°07.79	17°52.92	174	start	
			4:34	70°06.73	18°06.83	345	end	20587
409-1			14:40	70°09.55	17°53.95	324	start	
			15:54	70°08.54	18°07.81	337	end	20567
409-2			16:00	70°08.77	18°07.92	280	start	
			16:49	70°09.80	17°54.20	318	end	20187
411-1	Stjernsund	25.07.2005	3:53	70°15.60	22°32.92	392	start	
			4:25	70°17.28	22°24.42	366	end	3764
411-2			4:34	70°17.11	22°24.03	398	start	
			5:05	70°15.44	22°32.53	466	end	3764
411-3			5:13	70°15.27	22°32.13	470	start	
			5:55	70°16.93	22°23.65	402	end	3589
411-4			6:03	70°16.77	22°23.22	405	start	
			6:41	70°15.09	22°31.76	469	end	3231
425-1			23:56	70°17.46	22°24.86	109	start	
		26.07.2005	0:31	70°15.79	22°33.30	190	end	4075
425-2			1:12	70°17.03	22°23.80	401	start	
			1:23	70°16.58	22°22.85	407	end	1178
425-3			2:02	70°14.90	22°31.42	326	start	
			2:06	70°14.79	22°31.21	322	end	180
425-4			2:47	70°16.47	22°22.58	355	start	
			2:53	70°16.28	22°22.25	161	end	180
425-6			3:05	70°15.51	22°26.20	227	start	
			3:29	70°15.49	22°32.63	467	end	2275
425-7			3:43	70°14.58	22°37.69	468	start	
			3:50	70.14.48	22°37.53	469	end	180
425-8			4:07	70°15.40	22°32.40	444	start	
			4:25	70°15.15	22°31.91	472	end	379
425-9			4:40	70°14.23	22°37.17	470	start	
			4:47	70°14.00	22°36.77	459	end	379
432-1	Sotbakken		22:52	70°39.89	20°11.01	194	start	
			23:37	70°38.79	19°56.35	205	end	20645
432-2			23:44	70°38.58	19°56.46	209	start	
		27.07.2005	0:33	70°39.66	20°11.17	201	end	20645
432-3			0:38	70°39.42	20°11.34	198	start	
			1:21	70°38.34	19°56.57	207	end	20645
432-3			1:25	70°38.11	19°56.68	243	start	
			2:08	70°39.17	20°11.50	206	end	20645
461-1	Sotbakken		23:55	70°38.94	20°11.66	201	start	
		29.07.2005	0:50	70°37.86	19°56.73	238	end	20655

461-2			0:56	70°37.62	19°56.84	230	start	
			1:50	70°38.70	20°11.83	201	end	20655
461-3			1:56	70°38.49	20°12.04	195	start	
			2:53	70°37.40	19°57.00	211	end	20655
461-4			2:59	70°37.17	19°57.11	219	start	
			3:50	70°38.25	20°12.21	201	end	20655
461-5			3:57	70°38.04	20°12.43	215	start	
			5:04	70°36.90	19°57.22	194	end	20750
461-6			5:11	70°36.66	19°57.22	202	start	
			5:59	70°36.68	20°12.21	164	end	20640
461-7			6:06	70°36.90	20°12.21	165	start	
			6:59	70°36.92	19°57.22	195	end	20640
481-1	Stjernsund	30.07.2005	21:00	70°15.79	22°33.30	61	start	
			22:03	70°13.99	22°49.99	477	end	6466
481-2			22:10	70°13.68	22°49.82	479	start	
			23:20	70°13.62	22°32.90	418	end	6451
481-3			23:26	70°15.44	22°32.57	464	start	
		31.07.2005	0:34	70°13.35	22°49.88	477	end	6823
481-4			0:41	70°13.02	22°49.91	463	start	
			1:57	70°15.36	22°32.31	460	end	6823
481-5			2:01	70°15.21	22°32.01	473	start	
			2:50	70°12.68	22°49.82	311	end	7266
481-6			2:54	70°12.56	22°49.79	120	start	
			3:50	70°14.32	22°36.67	469	end	5414
481-7			3:58	70°14.11	22°36.33	464	start	
			4:18	70°13.28	22°43.49	49	end	2881
481-8			4:24	70°13.13	22°43.32	228	start	
			5:20	70°14.84	22°30.95	246	end	5057

CTD Measurements and water sampling

Andres Rüggeberg, Wolf-Christian Dullo, Sascha Flögel

A total of fifty-five CTD casts were carried out during R/V POSEIDON cruise 325. The purpose of these measurements was to perform hydrographic transects across the cold-water coral reef structures at Traenadjupet, Røst, Sveinsgrunnen and Stjernsund. Bottom water samples were collected for stable isotope ($\delta^{18}O$, $\delta^{13}DIC$, $\delta^{88}Sr$) analyses, as well as for the characterisation of bacterial communities of coral reef sites at Traenadjupet, Røst and Stjernsund (Table 4).

Another objective was to investigate the temporal variability of the influence of tidal waves and/or internal waves at the water mass boundary close to the coral reef structures. Therefore, CTD profiles were performed west and east of the Stjernsund sill with ~40 minutes interval between each station (80 minutes interval between each eastern or each western station).

The CTD system used is a SeaBird Electronics, model 911 plus type. The underwater unit was built into a rosette housing capable of holding 12 water sampler bottles. Pre-cruise laboratory calibrations of the temperature and pressure sensors were performed. Both yielded coefficients for a linear fit. The oxygen sensor must be considered unreliable because no in-situ measurements were carried out during the cruise. However, the general downcast trend of dissolved oxygen seems to follow previous studies (e.g. WOCE Global Data, World Ocean Database 2001, see: Conkright et al. 2002).

Table 4. CTD and water sampling stations of P325.

Station	Area	Date	Time	Coordinates		Depth	Remarks
#			(UTC)	Lat. (°N)	Long. (°E)	(m)	(xxx) = depth in metres
338	Traena-	16.07.2005	5:52	66°53.50	11°07.47	379	4 bottles (375, 364, 51, 11)
354	djupet		22:43	66°58.15	11°07.27	313	2 bottles (313, 304)
360		17.07.2005	14:58	66°58.42	11°06.54	299	4 bottles (3x297, 286)
362			21:16	67°10.13	09°18.53	479	3 bottles (478, 467, 439)
373	Røst Reef	19.07.2005	14:44	67°31.51	09°29.40	315	2 bottles (310, 298)
374			15:24	67°31.60	09°29.60	316	2 bottles (315, 304)
375			16:00	67°31.66	09°29.83	308	2 bottles (304, 292)
376-1			16:39	67°31.75	09°30.16	330	2 bottles (319, 306)
376-2			17:12	67°31.77	09°30.21	329	2 bottles (318, 307)
377			17:50	67°31.81	09°30.31	346	2 bottles (331, 320)
378			18:31	67°31.58	09°30.40	271	2 bottles (265, 254)
379			19:07	67°31.65	09°30.16	320	2 bottles (305, 294)
380			19:42	67°31.77	09°29.80	323	2 bottles (322, 311)
381			20:46	67°31.88	09°29.48	338	12 bottles (10 x 336, 2 x 324)
383	Sveins-	21.07.2005	22:44	69°43.01	16°07.48	1040	3 bottles (1039, 593, 298)
386	grunnen	22.07.2005	7:20	69°42.46	16°14.02	188	4 bottles (188, 175, 50,10)
393			12:54	69°42.69	16°11.45	323	—
394			13:44	69°42.82	16°09.81	523	—
395			14:38	69°42.95	16°08.60	718	—
396	Fugløyb.		20:16	70°07.74	18°07.98	383	2 bottles (383, 371)
410	Stjernsund	25.07.2005	3:15	70°14.93	22°35.47	467	2 bottles (464, 453)
418			17:33	70°15.51	22°31.37	420	2 bottles (411, 401)
419			18:30	70°15.74	22°30.46	369	2bottles (363, 350)
420			19:06	70°16.00	22°29.11	253	3 bottles (248, 248, 237)
421			19:42	70°16.01	22°28.46	210	2 bottles (213, 210)
422			20:17	70°16.19	22°28.15	298	2 bottles (299, 288)
423			20:55	70°16.36	22°27.07	362	2 bottles (359, 349)
424			21:40	70°16.65	22°25.40	388	2 bottles (383, 374)
410-2			22:47	70°14.86	22°34.98	467	2 botttles (463, 455)

431	Sotbakken	26.07.2005	22:02	70°37.91	20°03.57	256	
435	Stjernsund	27.07.2005	16:54	70°15.76	22°30.64	375	only casting
436			17:41	70°16.38	22°27.24	363	only casting
437			18:33	70°15.75	22°30.50	374	only casting
438			19:08	70°16.39	22°27.20	362	only casting
439			19:53	70°15.74	22°30.49	372	only casting
440			20:29	70°16.41	22°27.21	361	only casting
441			21:05	70°15.73	22°30.47	367	only casting
442			21:42	70°16.39	22°27.23	361	only casting
443			22:18	70°15.74	22°30.59	371	only casting
444			22:57	70°16.39	22°27.18	361	only casting
445			23:42	70°15.73	22°30.49	366	only casting
446		28.07.2005	0:19	70°16.37	22°27.20	360	only casting
447			1:02	70°15.70	22°30.52	368	only casting
448			1:45	70°16.40	22°27.19	361	only casting
449			2:34	70°15.71	22°30.50	370	only casting
450			3:27	70°16.42	22°27.21	362	only casting
451			4:03	70°15.64	22°30.81	369	only casting
452			4:40	70°16.37	22°27.31	361	only casting
453			5:15	70°15.83	22°30.73	378	only casting
454			5:53	70°16.37	22°27.20	372	only casting
475	Stjernsund	30.07.2005	17:24	70°15.55	22°27.57	212	only casting
476			17:57	70°16.06	22°28.39	216	only casting
477			18:30	70°16.42	22°28.97	264	only casting
478			19:00	70°15.72	22°27.84	210	only casting
479			19:31	70°16.26	22°28.66	237	only casting
480			20:16	70°15.88	22°28.24	231	only casting

Seabed Sampling

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We used three different types of gear for geological and biological sampling. A small Van Veen grab (Fig. 4) was used for quick and reconnaissance sampling purposes. This grab was also used in areas rich in live corals in order to minimise damage to the benthic habitat. In total, 50 grab stations were carried out (Table 5).

Fig. 4. The Van Veen grab used on P325.

Table 5. Van Veen grab station list.

Station	Area	Date	Time	Lat. (°N)	Long. (°E)	Depth	Remarks
342	Traena-	16.07.2005	17:05	66°58.07	11°07.93	314	pebbly sand
343-1	djupet		17:29	66°58.14	11°07.90	322	live coral
343-2			17:41	66°58.17	11°07.74	322	pebbly sand, sponges
344			18:08	66°58.14	11°07.79	313	pebbly sand, coral rubble
346			18:58	66°58.18	11°07.74	322	pebbly sand
347			19:34	66°58.25	11°07.59	321	pebbly sand
348			19:55	66°58.28	11°07.61	321	pebbly sand
349			20:27	66°58.19	11°07.34	312	reef top
350			20:52	66°58.15	11°07.31	317	pebbly sand
351			21:18	66°58.08	11°07.44	319	pebbly sand
352			21:41	66°58.02	11°07.71	317	pebbly sand
353			22:05	66°57.96	11°07.83	317	pebbly sand
367	Røst Reef	19.07.2005	8:17	67°31.67	09°29.83	310	coral rubble
368			8:46	67°31.62	09°29.63	325	stiff clay
369			9:15	67°31.74	09°30.14	331	live corals
370			9:58	67°31.23	09°28.59	315	coral rubble
371			10:40	67°31.43	09°28.43	368	pebbly sand
372			11:48	67°30.44	09°25.52	303	live corals
387	Sveins-	22.07.2005	8:10	69°42.00	16°14.99	163	boulders
388	grunnen		8:56	69°42.53	16°21.75	289	boulders, bioclastic sand
389			9:23	69°42.52	16°21.02	302	boulders, bioclastic sand
390			9:50	69°42.76	16°18.64	327	boulders, bioclastic sand
391			10:53	69°42.79	16°15.99	282	boulders, bioclastic sand
392			11:34	69°42.72	16°15.07	255	boulders, bioclastic sand
398-1	Fugløyb.	23.07.2005	5:09	70°07.47	18°04.66	283	failed
398-2	Trough		5:39	70°07.42	18°04.61	301	boulder
399			6:19	70°07.83	18°04.68	288	lag-deposit
400			7:39	70°08.53	18°04.21	276	pebbly sand
401			8:25	70°08.43	18°05.42	302	pebbles, silty sand
402			8:51	70°08.36	18°06.48	337	pebbles, silty sand
403			9:19	70°07.87	18°07.11	360	pebbles, silty sand
404			9:59	70°06.85	18°02.23	236	Bryomol sand
405			10:45	70°07.13	18°00.16	228	pebbles
406			11:38	70°07.51	17°57.51	157	Bryomol sand
407-1			12:06	70°07.84	17°54.96	262	Bryomol sand
407-2			12:34	70°07.84	17°54.94	260	Bryomol sand
408			13:23	70°08.75	17°56.78	352	clayey silty sand
413	Stjernsund	25.07.2005	12:50	70°15.83	22°28.84	248	coral rubble
414			13:01	70°15.86	22°28.59	245	coral rubble
415			13:17	70°15.99	22°28.35	236	coral rubble
416			13:28	70°16.13	22°28.54	208	live corals
426		26.07.2005	6:29	70°15.88	22°28.77	257	coral rubble
427			7:05	70°16.29	22°28.75	225	coral rubble
462	Sotbakken	29.07.2005	7:55	70°39.07	20°06.37	193	sand
463			8:48	70°38.98	20°03.76	193	sand
464			9:34	70°38.65	19°57.49	209	sand
465			10:32	70°38.15	20°08.70	229	boulders
466			11:24	70°37.98	20°06.63	267	boulders
467			12:12	70°38.12	20°06.28	237	boulders

The box-corer consists of a 50x50x60 cm sampling box and was in operation on 9 stations (Table 6). Box-corer stations yielding sufficient sediment recovery are treated in the same way: (1) Description of the sediment surface and fauna including photographic documentation of special features. (2) Sampling of the sediment surface with two 200 cm^2 sub-samples for micropaleontological studies. One set of these sub-samples was stained with a solution of 1g of rose bengal in 1 l ethanol. The stained sub-samples are stored at the IFM-GEOMAR while the non-stained sub-sample set remains in the Paleontological Institute, Erlangen, University. (3) Sampling of macrofauna with subsequent fixation in ethanol. (4) The entire sediment column was logged (including photo documentation) and subsamples were (syringes) were taken for grain-size and micropaleontological studies. (5) Two sets of archive-cores were taken (storage at IFM-GEOMAR and Erlangen University). (6) The remaining sediment column was sieved stratigraphically in 10 cm-thick slices (or thinner in respect to the thickness of the sedimentary units) over a series of sieves with 2 cm, 1 cm and 0.5 cm mesh-size.

Table 6. Box-corer stations on P325.

Station	Area	Date	Time	Coordinates		Depth	Recovery
#			(UTC)	Lat. (°N)	Long. (°E)	(m)	
357	Traenadjupet	16.07.2005	12:08	66°58.23	11°07.63	315	38cm
358			13:10	66°58.13	11°07.82	314	42cm
430-1	Stjernsundet	26.07.2005	14:45	70°16.50	22°23.07	407	failed
430-2			15:11	70°16.50	22°23.07	407	46cm
434-1		27.07.2005	14:49	70°15.02	22°32.81	472	empty
455		28.07.2005	6:36	70°16.13	22°29.46	270	10cm
456-1			7:16	70°16.24	22°28.61	236	poor
456-2			7:39	70°16.25	22°28.57	249	35cm
482-1		31.07.2005	7:39	70°13.86	22°47.78	478	56cm

In order to obtain sediment cores we used a gravity-corer either with a 3 m or a 6 m barrel (Fig. 5). This gear was used on 12 stations (Table 6). The cores were cut in 1-m sections but remained cooled and closed during the cruise and will be stored at the Institute of Paleontology, Erlangen University for further investigation.

Fig. 5. Gravity-corer with a 6 m barrel.

Table 6. Gravity-corer station list.

Station	Gear	Area	Date	Time	Coordinates		Depth	Recovery
#				(UTC)	Lat. (°N)	Long. (°E)	(m)	
359	SL-6m	Traenadjupet	17.07.2005	14:05	66°58.24	11°07.63	315	564cm
430-3	SL-6m	Stjernsund	26.07.2005	15:52	70°16.50	22°23.10	407	450cm
434-2	SL-6m		27.07.2005	15:36	70°14.99	22°32.81	472	no recovery
457	SL-3m		28.07.2005	8:20	70°16.24	22°28.63	240	300cm
458	SL-6m			8:51	70°16.13	22°29.44	272	no recovery
459	SL-6m			9:18	70°16.25	22°28.60	258	300cm
470	SL-6m		30.07.2005	6:21	70°16.39	22°25.81	386	550cm
471	SL-6m			7:00	70°15.85	22°28.23	226	210cm
472	SL-6m			7:38	70°15.68	20°28.92	262	600cm
473	SL-6m			8:12	70°15.49	20°30.22	361	110cm
482-2	SL-6m		31.07.2005	8:24	70°13.85	22°47.63	479	600cm
483	SL-6m			9:50	70°15.80	22°26.98	358	empty

4 Preliminary results

Træna Reefs

Background.— The Traenadjupet is a large glacial-eroded trough perpendicular to the coastline with maximum water depths of 450 to 500 m. The trough dissects the shelf in NW-SE direction with the Røst Bank in the north and the Træna Bank in the south (Fig. 6). At the SE end, the trough merges with the shallower Vestfjorden Trough framed by the Lofoten Islands and the Norwegian mainland. The entire Vestfjorden-Traenadjupet system represents a giant palaeo-ice stream drainage system (Ottesen et al. 2005). Clear seabed indications of this ice stream are large ridges parallel to the ice flow direction. The presence of coral reefs in the inner Trænadjupet area became known to science by Hovland & Mortensen (1999) who interpreted side scan sonar survey data carried out in 1992. Parts of the sonographed area were re-visited using a multibeam system for comparative studies in 2003 (Fosså et al. 2005). The survey data confirm the existence of approximately

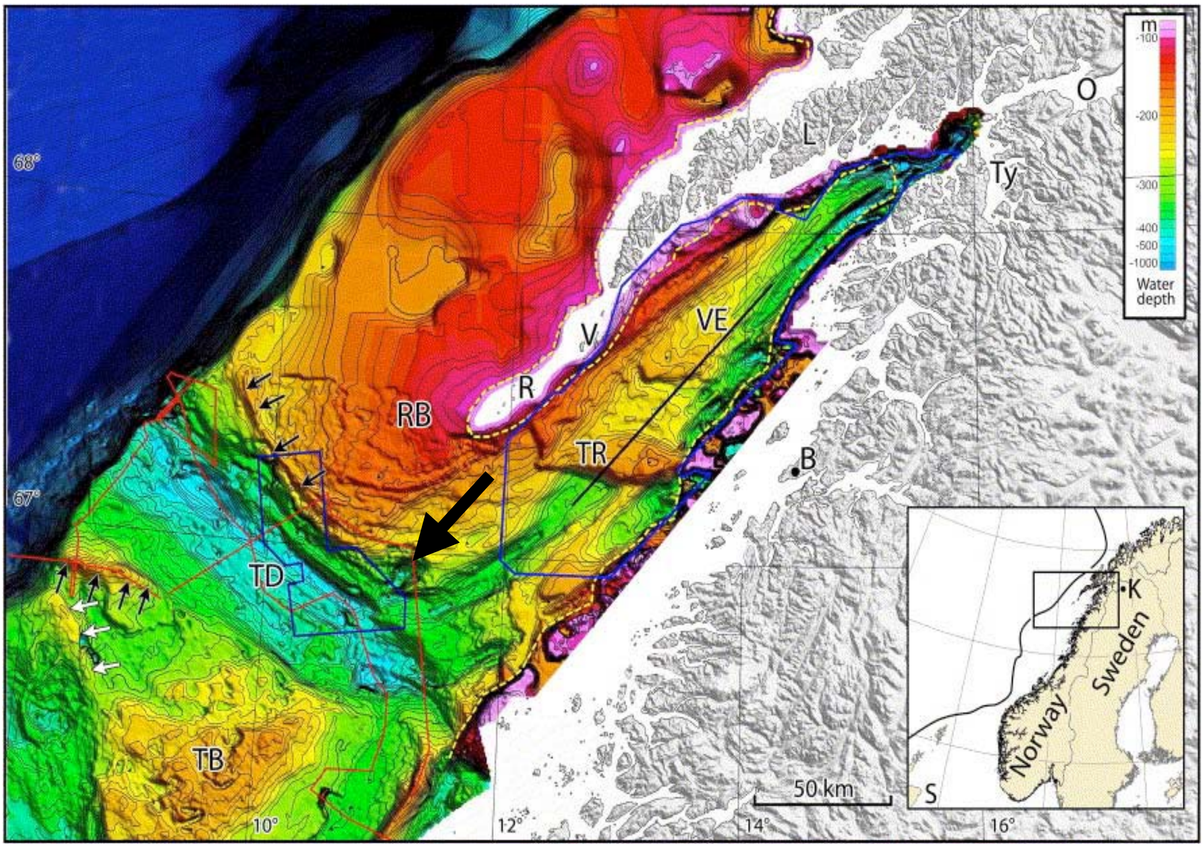

Fig. 6. The Vestfjord (VE) – Trænadjupet (TD) palaeo-ice stream drainage system off Bodø. Thick black arrow points to the P325 study area, the northern rim of a bowl-shaped morphological depression where hundreds of coral reefs are aligned in a contour-parallel fashion. This map is slightly modified from Ottesen et al. (2005) where all other symbols and abbreviations are explained.

fifteen hundred coral reefs in the mapped area. A few weeks prior to the P325 cruise, a RV G.O. SARS cruise under the auspice of the Institute of Marine Research inspected this area with a ROV and took a couple of grab samples to groundtruth the architecture of the suspected reefs, sediment types and organism assemblages for the HERMES project.

P325 activities.— In order to deepen the knowledge of these reefs, P325 carried out a survey in one of the IMR sites with a special focus on the geological evolution of the reefs after the last glacial period. The area of interest centres at N66°58 and E011°07 and covers about 18 km^2 at the northern end of a bowl-shaped seabed depression (see Fig. 6) with shallower depths of 290-300 m at the northern and western margin and greater depths of 330 m at the SE corner of the mapped area (Fig. 7). Within this grid, we carried out 2 CTD/water sampling stations (#354, 360), 12 grab stations (#342 – 353), 2 box-corer stations (#357 – 358) and 1 gravity-corer loaded with a 6 m barrel (#359). In addition, two JAGO dives (# 341, 356) documented the reef structures and off-reef facies in great detail. Most of the work concentrates in the eastern half of the mapped area (Fig. 7).

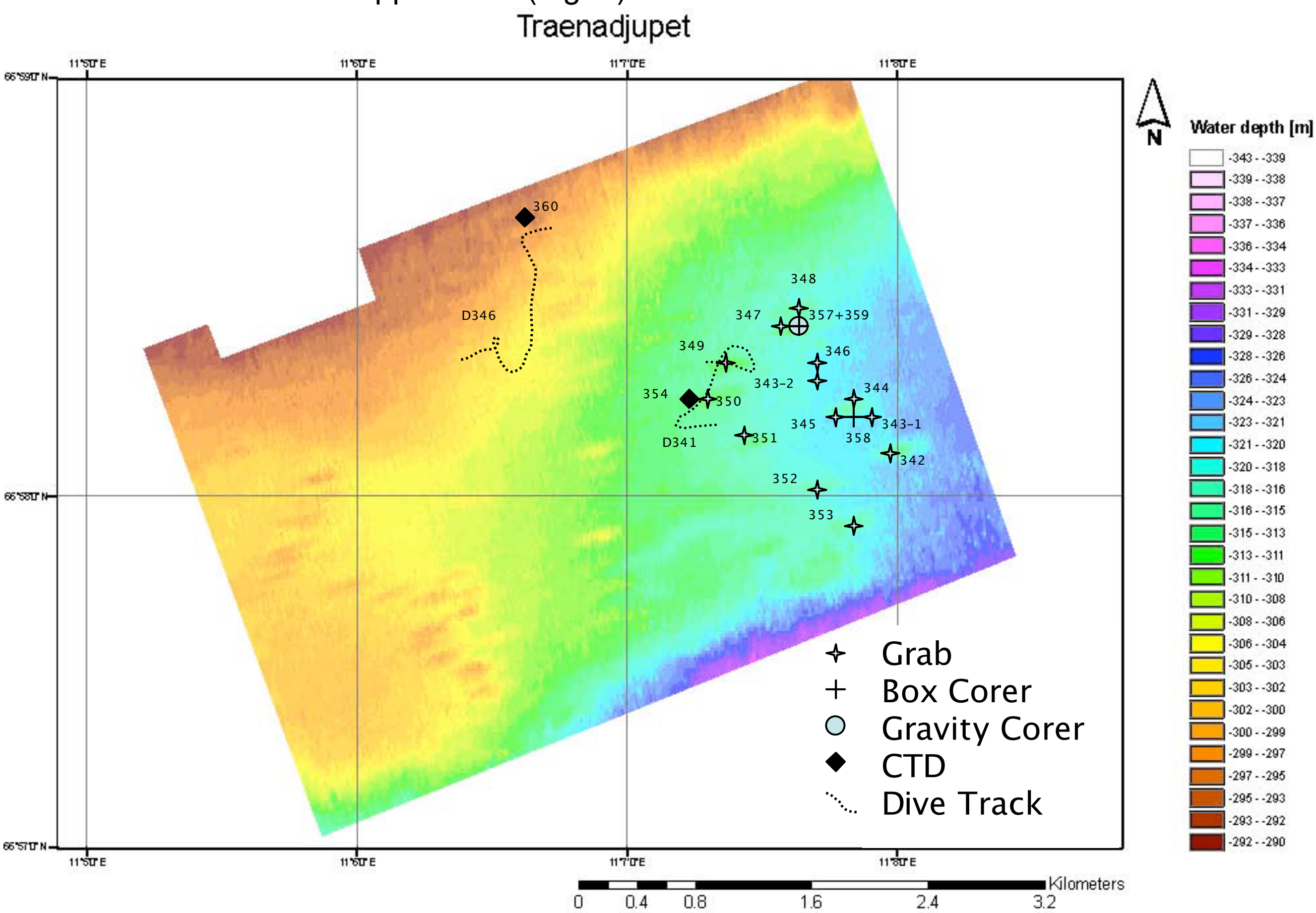

Fig. 7. Multibeam map showing the scientific activity of P325 in an area of 36 low-relief coral reef mounds. The reef mounds are consistent in terms of size (100 to 400 m across, are 40 to 60 m wide and about 4 to 6 m thick), form (elongated) and orientation (SW-NE).

Hydrography.— The CTD-casts yielded water temperatures around 12°C at the surface which drops down to c. 7°C at the seabed. Salinity values of 35 ‰ PSU were encountered throughout the entire water column with slightly lower values near the surface. A thermocline was detected at 50 – 100 m depth (see Chapter on CTD measurements for more details).

Background (offreef) seabed: sediments, structures and fauna.— The seabed has a gently undulating surface with height differences of 1 to 1.5 m over a distance of about 100 m. The surface sediment is variable. Remarkable stiff olive-grey clayey sediment, speckled with polymict dropstones crops out. This sediment type is overlain with a more sandy and dropstone-rich layer in places (Fig. 8). Corroded

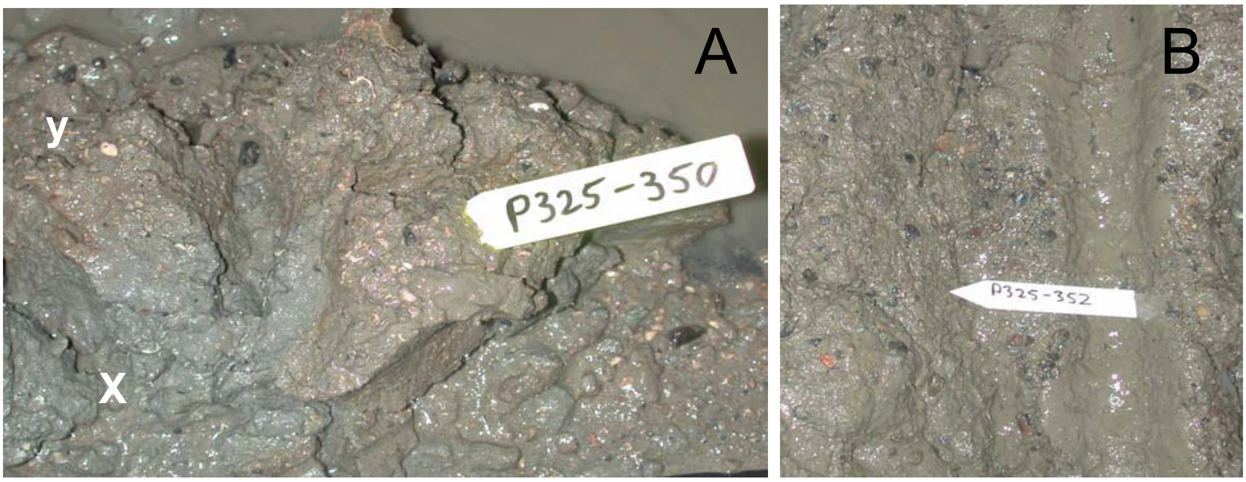

Fig. 8. Grab stations #350 and #352 exemplify characteristic features of surface offreef sediments. **A** Stiff grey clay with few dropstones (x) is covered by a sand and dropstone-rich surface layer (y). **B** Impression of the dropstone-rich sediment surface (length of the labels = 10 cm).

shells of molluscs commonly occur in this sediment facies. Locally, boulder fields are concentrated on the uppermost parts of the gently undulating seabed. Benthic life is rich in the offreef seabed. The soft sediments are inhabited by ophiuroids, asteroids and occasional holothurians and sea pens. Burrows of sqat lobsters and *Bonellia* cf. *viridis* occur in great densities in areas covered by the sand-rich surface sediment. Another faunistic aspect of the sand fields is the great quantity of *Thenea* sponges, brachiopods and ascidians (Fig. 9A). Especially the demosponges seem to stabilise the sediment. The boulders are densely colonised by sponges (*Phakellia, Mycale, Pachastrella, Hymedesmia*), brachiopods, bryozoans, hydroids, serpulids and foraminifers (Fig. 9B).

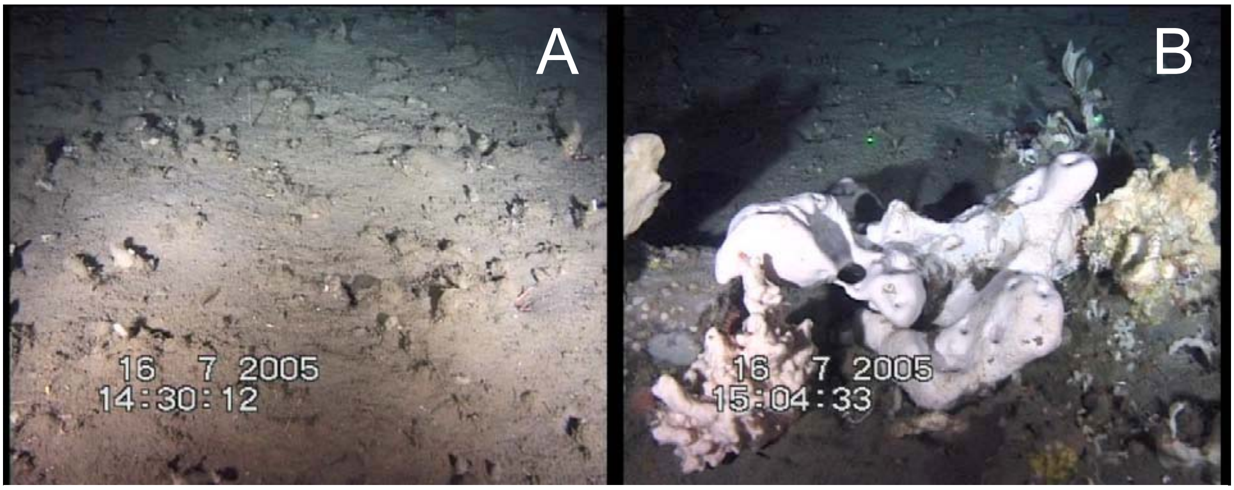

Fig. 9. Faunal aspects of the offreef seabed. **A** Sand fields are densely occupied by *Thenea* sponges and ascidians acting also as stabilisers of the seabed. **B** Boulders provide substrate for a diverse benthic community. Both framegrabs derive from JAGO dive #341 at 318 m depth.

It is not too much of speculation to interpret the offreef sedimentary environment as follows: The gently undulatory seabed may be related to the palaeo-ice stream striations created by waning and waxing glaciers as described by Ottensen et al. (2005). The stiff clays may be either of morainic or glaciomarine origin but certainly can be related to the glacial or early postglacial depositional regime. The sand and dropstone-rich surface sediments can be interpreted as lag-deposits admixed with modern sedimentation. Tentatively, these sediments may have been formed during the Late Pleistocene to Early Holocene transition, when drifting icebergs released huge quantities of ice-rafted detritus during the deglaciation period. Due to the high current regime, Recent sediment accumulation rates seem to be rather low as the fine-grained detritus is kept in suspension. This latter aspect is beneficial for sponges and accounts for the diverse and often dominating aspect of the sponges in the offreef benthic assemblages.

Coral reef mounds.— As has been pointed out by Fosså et al. (2005), the coral reef mounds are remarkably consistent in terms of dimension, shape and orientation. Individual mounds measure 100 to 400 across and are 40 to 60 m wide. Also the height of the biogenic structures varies between 4 and 6 m. All are elongated in shape with a SW-NE orientation which corresponds to the prevailing current direction in this area. Within the mapped area of 18 km^2, 36 low-relief mounds can be identified accounting for 1 reef mound per 2 km^2. Fosså et al. (2005) who mapped a much larger area in the Trænadjupet region counted some fifteen hundred reef mounds. Provided that coral growth rates where the same in the wider region, all these general aspects point to (a relatively) sudden onset of reef mound evolution somewhere during the Holocene, when oceanographic and climatic conditions allowed the successful settlement and the survival of coral larvae to form coral colonies which eventually form reefs with time. To solve the question of the postglacial reef pulse in northern Norwegian waters, we were able to core the entire reef sequence of a 5-m-thick reef mound located at N66°58.24 and E111°07.63 at 315 m depth with a gravity corer (#359; see Fig. 7). The core catcher stuck deep within the stiff clay underneath the reef. The most striking aspect, however, is the almost subfossil nature of the reef mounds. Out of the 36 mounds mapped in this area, only 7 were inspected with the manned submersible. All these reef mounds now represent sediment-clogged coral framework and coral rubble facies (according to the sedimentary facies terms defined in Freiwald et al. 2002; Fig.

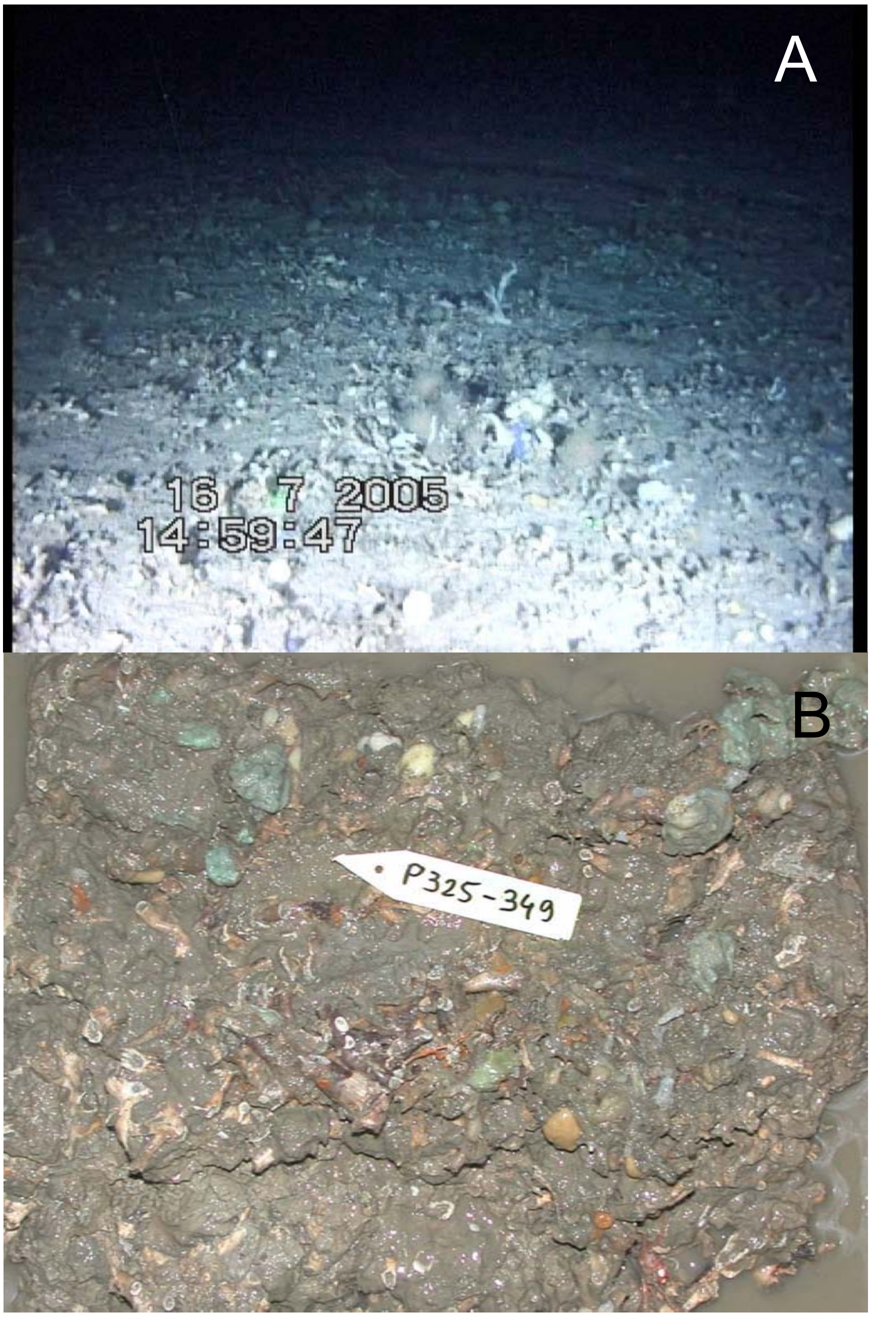

Fig. 10. A The flat roof of the subfossil coral reef mounds show no life coral coverage. Instead, an epilithic sponge-dominated assemblage prevails (Framegrab from JAGO dive #341 at 315 m depth).
B Sediment surface of grab station #349 shows the sediment-clogged coral rubble facies. Exposed coral skeleton are Fe-Mn-stained and are encrusted by pale-green sponges.

10). The transition between the flat seabed and the reef mounds is rather sharp and consists of a 3 to 5 m broad belt of coral rubble and bioclastic sand.

The fact that the flat offreef seabed started to lift up already about 30 to 50 m in front of the reef mound indicates a link to pre-existing topographic heterogeneities that have attracted the corals to accumulate on the highest seabed structures in the area studied. The reef mound flanks slope up with 25° to 40° dipping angle. On Dive 341, we encountered a current-outwashed flank of a mound that allows an outcrop-like view into the internal composition of a reef mound. The flank is made of fossil but rather intact and thickly calcified colonies of *Lophelia pertusa* corals, interspersed by layers of coral rubble and shell plasters of the file clam *Acesta excavata*. The top the

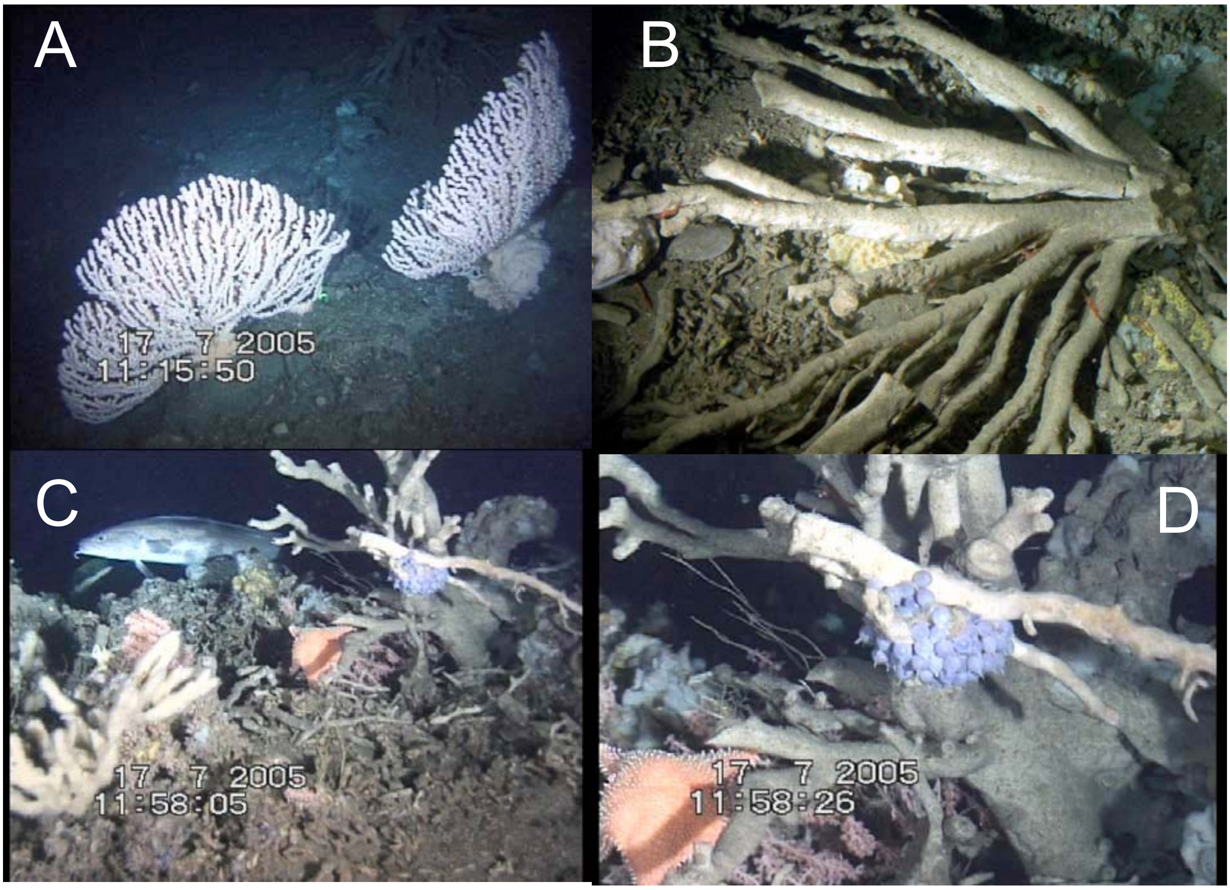

Fig. 11. The up-current facing NE ends of the reef mounds are rich coral and sponge colonies which indicate pleasant ecological conditions compared to the other parts of the reef mound. **A** Two 50 cm tall *Paragorgia arborea* who have exposed their fan-shaped colonies perpendicular to the current (Dive 356). **B** Remains of a dead *Paragorgia* colony (Dive 341). **C** Octocoral thicket guarded by *Brosme brosme.* Note the eggcases of a sepioid cephalopod (blue eggs). **D** Close-up of **C** showing the cephalopod eggcases (Dive 356).

reef mounds inspected is smooth and consist of coral rubble clogged with fine-grained sediment enriched with calcareous skeleton of the coral-associated fauna (see Fig. 10).
Most active life only exists at the up-current facing NE ends of the reef mounds. Here, huge fans of *Paragorgia arborea* (see Fig. 11), *Primnoa resedaeformis* (Fig. 12E), several huge demosponges and the remaining life *Lophelia pertusa* colonies typically were found. The morphology of the mound ends (or growing 'heads') often shows a stepped descent towards the adjacent seabed. Near the base, huge boulders pierce through the coral rubble debris, thus indicating the initial colonisation substrate of the pioneering coral reef stage? There exist large differences in the quantity of life *Lophelia* in the proliferating heads of the mounds. While some mounds visited show no or very sparse life corals, other mounds still have up to 2 m thick and 5 m wide spheroidal colonies, which – if merged with adjacent ones – form a dense wall or hedge of corals with all polyps directed against the current (Fig. 12A). However, this living "skin" of corals is rather thin and measures 10 cm on average only (Fig. 12B-C). This is much less compared with the living corals on Sula Reef further south and underlines the vulnerability of the Træna coral occurrences. In some examples, these huge coral colonies are so mature, that they show signs of internal collapse with fractures and fissures (Fig. 12D) initiated through a process called bioerosion of boring sponges and other endoliths (Beuck et al. 2005). Broken coral skeletons often show sponge excavations in these older parts of the colonies. The fissures provide shelter especially for *Brosme brosme* (see Figs. 11C, 12A, C) that shows a pronounced territorial behaviour. Each larger coral colony was guarded by one *Brosme* fish. Another aspect that may document worsening life conditions for the corals is related to the calcification potential. The thickness of the dead coral skeleton, the theca, is much thicker calcified than in the extant corals which resemble dwarfed forms (Fig. 12 B). The dead and exposed coral skeleton is coated with Fe-Mn-rich biofilms (see Freiwald & Wilson 1998) and indicate dysoxic conditions at the cellular level. This is another line of evidence that the present ecological conditions at Træna are not favourable for *Lophelia* compared with former times in the recent past.
To conclude, proliferating scleractinian coral growth of the reef mounds is restricted to the NE-facing up-current heads. A similar biozonation was observed in the elongated "lithoherms" in the Florida Strait by Messing et al. (1990). Molecular

genetic studies are needed to test the hypothesis weather or not the Træna Reefs are in decline.

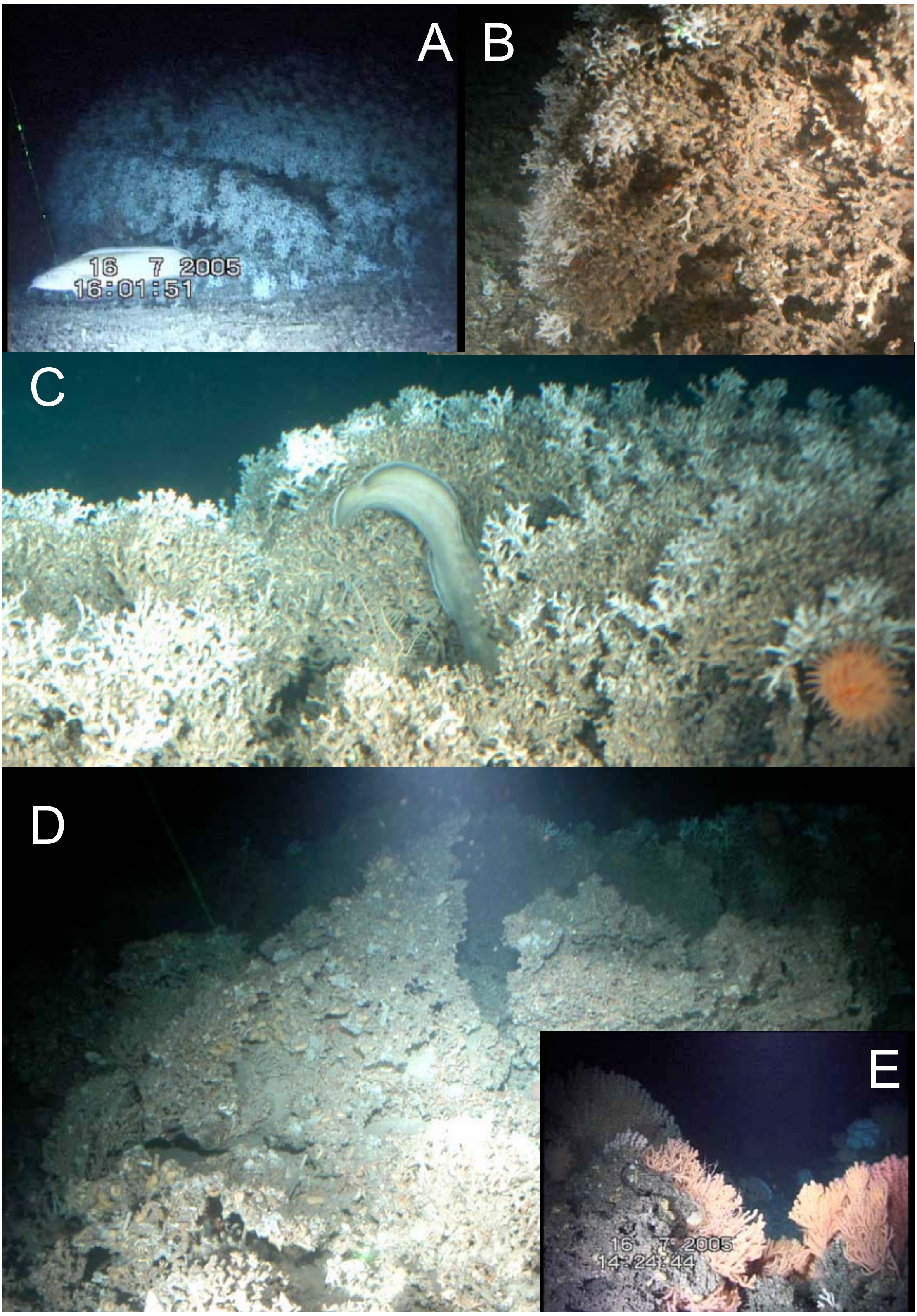

Fig. 12. The up-current facing *Lophelia* colonies on the reef mounds. **A** Dense „hedge“ of life corals with almost all polyps facing against the current. The fish (*Brosme brosme*) lives in the dead portions of this hedge seen at **C**. **B** Lateral view of the same hedge showing the thin living skin of corals and the Fe-Mn-coated portion of the dead coral skeleton. **C** *Brosme* enters his shelter within the coral colony. **D** Backview of the same hedge as in A shows the bioeroded and cracked part of the colony. **E** *Primnoa-Paragorgia* forest growing on another reef mound (**A-D** from Dive 341, **E** from Dive 356).

The Røst Reef area

Background.— In 2002, the large Røst Reef was discovered along the back wall of a giant submarine slide, the Trænadjupet Slide, that took place some 4000 years ago (Laberg et al. 2002). According to Fosså et al. (2005), the reef is about 35 to 40 km long and occurs in 300 to 400 m depth. The complex and rugged seabed topography provides attractive settling ground for the reef-constructing corals. Reef hosting bedforms can either be related to the slide in the form of pressure ridges along the seaward side of the shelf break, or to glaciomarine processes, such as iceberg ploughmark ridges (landward side of the shelf break). The Rost Reef Complex is one of the largest known in the world.

P325 activities.— The Røst Reef programme suffers from severe weather conditions and had to be abandoned too early. Therefore, no dives and no geological coring could be carried out in the main reef area. After a multibeam mapping survey (#364, 366), we were able to carry out 2 submersible dives (#363, 365) north of the known reef extension, 6 grab stations (#367-372) in the main reef area, and 10 CTD casts (#373-381) (Fig. 13).

The open slope: sediments and organisms.— JAGO Dive 363 took us to a steep-inclined, open slope section in 356 to 330 m depth with no topographic complexities such as pressure ridges but well within the bathymetric zone of *Lophelia pertusa* at N67°34.63 and E009°34.03. The slope sediment consists of greyish consolidated clays. On top of the clay, fields of boulders alternate upslope with cobble or pebble pavements (Fig. 14). Sand-sized sediments are almost lacking except as in the form of comet marks in the lee of boulders. This indicates a vigorous current regime. During the dive, the current constantly show a NE direction. We observed that cobbles are colonised by a different sponge assemblage compared to boulders. Next to sponges, actinians and alcyonarians (*Drifa* or *Capnella*) and stylasterids are commonly found on the hard substrates. The mobile fauna consist of sea spiders (*Maja lithodes*), *Gorgonocephalus*, ophiuroids, *Echinus* and *Cidaris* sea urchins, *Munida* squat lobsters (only if sand is present on the stiff clay), holothurians (*Stichopus* and others) with corresponding traces. At 344 m depth, boulders become increasingly overgrown by a grey to pale green encrusting sponge that resembles *?Halichondria* (Fig. 14).

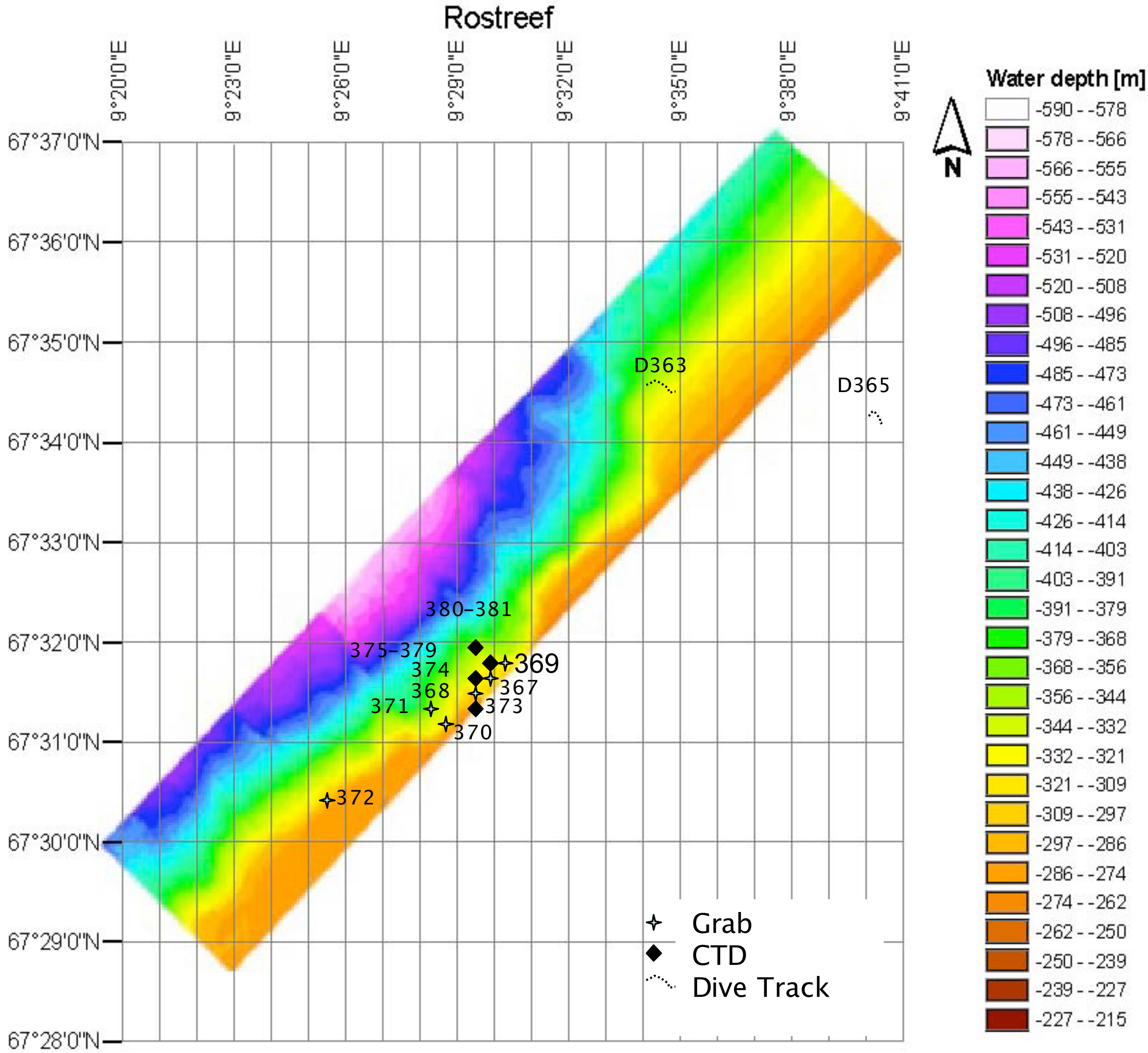

Fig. 13. Multibeam map and station plot in the Røst Reef area.

Fig. 14. Boulder and cobble pavement ontop of the consolidated clay. The open slope fauna is dominated by a diverse sponge assemblage (Framegrab from Dive 363).

The outer shelf.— The JAGO Dive 365 was aimed to inspect the outer shelf, a few hundred metres in front of the shelf break at N37°34.38 and E009°40.12 at depths of 253-245 m (Fig. 13). The most prominent feature encountered during this dive was a ploughmark with boulder levees that support a rich gorgonian-alcyonarian-sponge assemblage (Fig. 15A). Interestingly, only the current-exposed boulders (facing against the NE-directed residual current), are colonised by *Paragorgia arborea*. Scleractinians were not found during Dive 365. The flat seabed consists of a pebbly

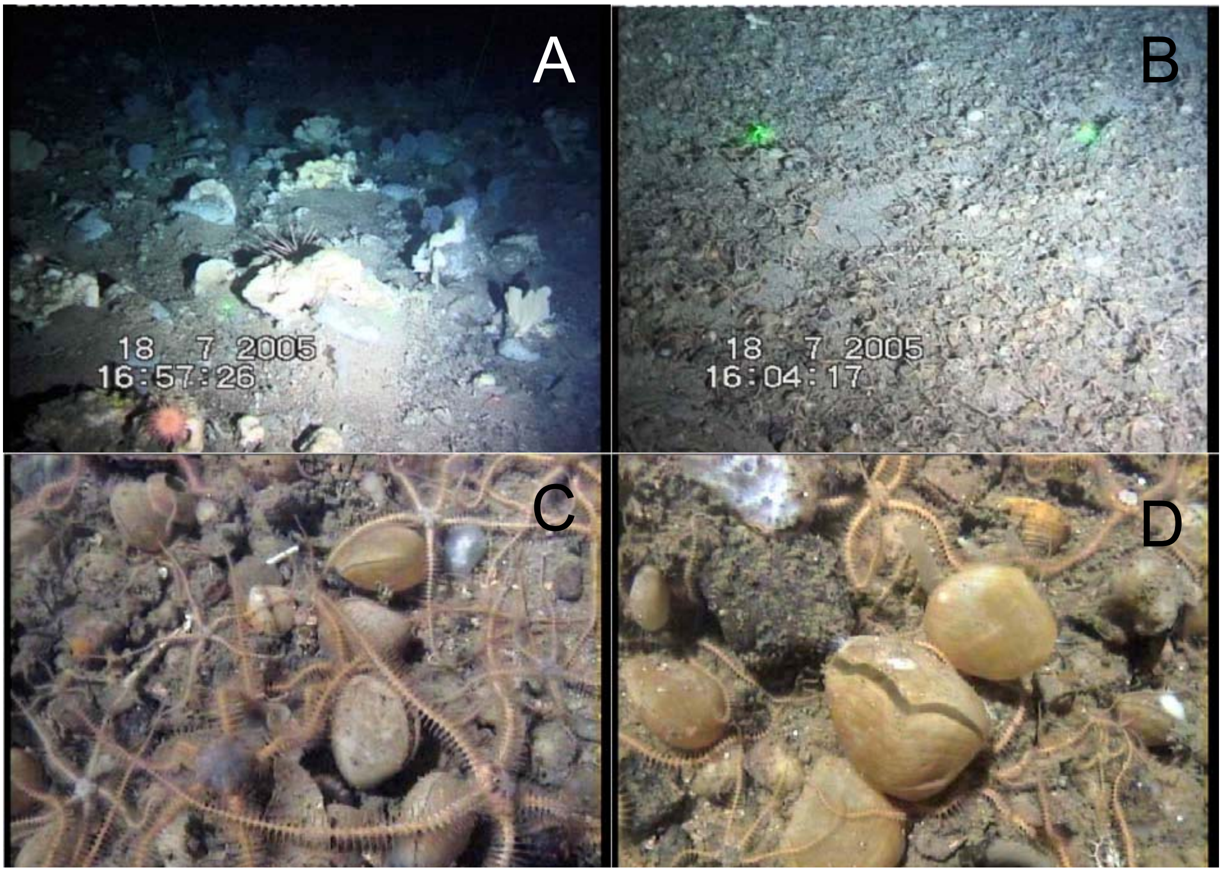

Fig. 15. A Characteristic megafauna of the boulder fields on the outer shelf at 250 m depth. **B** Flat seabed with pebble pavements are sites of ophiuroid-brachiopod mass occurrences (the two green laser dots have a distance of 50 cm). **B** and **C** show close-ups of the unique assemblage (all photos were taken on Dive 365).

Sveinsgrunnen Slope

Background.— The Sveinsgrunnen off Senja is a flat outer shelfbank with a steep slope resembling another slide escarpment (?). Fishermen reported the occurrence of *Lophelia* corals as cited in Fosså et al. (2000).

P325 activities.— We carried out a short scientific survey in the area of coral records which is the westernmost nose of Sveinsgrunnen. Our activities include a multibeam mapping survey (#385), a CTD transect (#383, 386, 393-395) and some grab stations (#387-392) (Fig. 16). The station work was hampered by large swell.

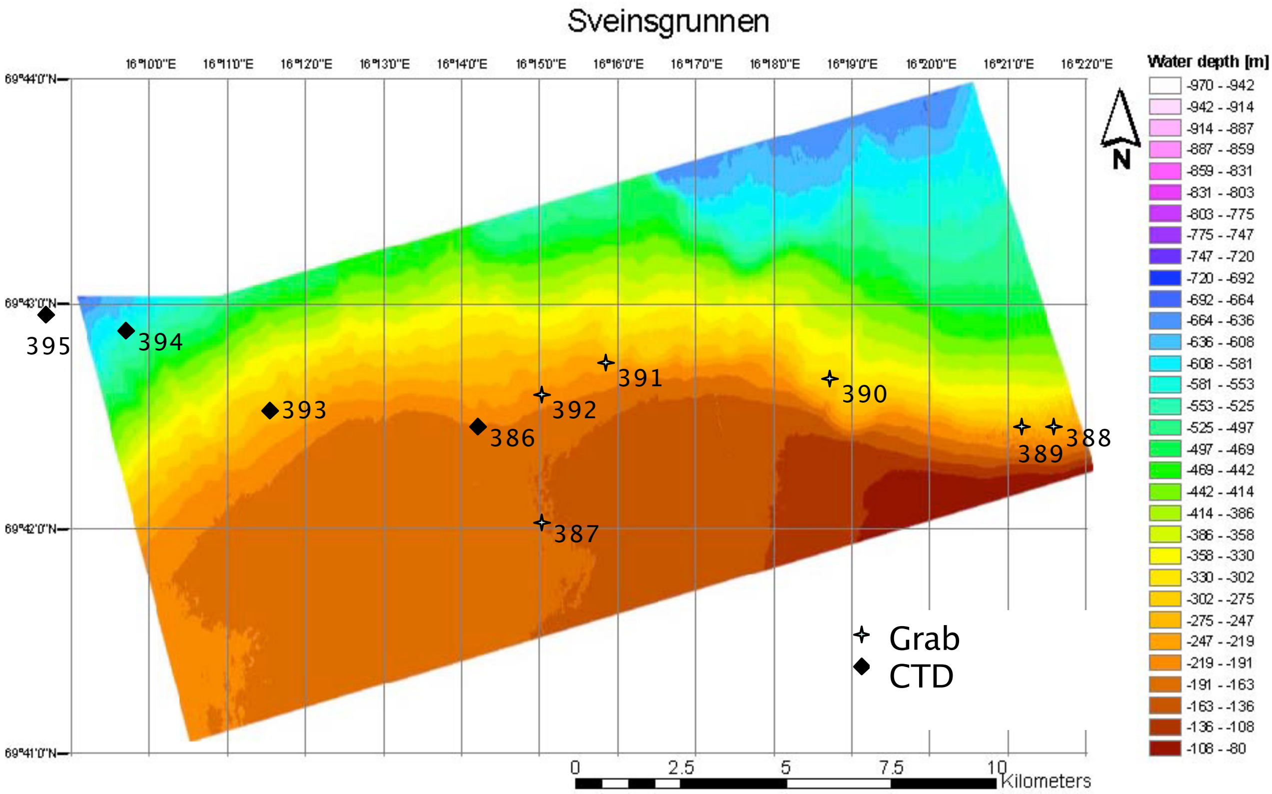

Fig. 16. Multibeam map and stations on the outer Sveinsgrunnen slope.

Slope sediments.— All grab samples revealed pebbly to boulder-rich sediments admixed with coarse siliciclastic and bioclastic sands. The boulders are densely encrusted by serpulids, bryozoans, brachiopods, stylasterids and foraminifers. One grab sample (#392) yielded the sediment underneath the coarse deposits which is a consolidated grey clay. Although, we tried to take the grabs from suspicious topographic hills or ridges, no corals or coral rubble was found. The first results of the hydrographic works are described in the chapter on CTD measurements.

Malangsgrunnen-Fugløybanken off Rebbensøy

Background.— The shelf off Troms is known for its variety of Holocene to Recent cool-water carbonate factories. The coastal platforms and skerry archipelagos harbour productive kelp forests with corresponding carbonate-secreting associated communities (Freiwald 1993, 1998) and a variety of coralline algal facies (Freiwald & Henrich 1994, Freiwald 1995). The open shelf bank communities produce skeletal sands, dominated by bryozoans, molluscs, serpulids and brachiopods and are formally described as Fugløybanken Sand, a mid-Holocene sedimentary unit (Vorren et al. 1978). This example of a characteristic BRYOMOL facies was intensely studied by Schäfer et al. (1996) for its diversity of bryozoans based upon samples from the northern slope of the Malangsgrunnen Bank collected during RV Meteor Cruise M13/1 (Gerlach & Graf 1991).

P325 Activities.— We focused on the trough separating Malangsgrunnen Bank from Fugløybanken. Off Rebbenesøy at N70°08 and E018°04, a N-S oriented sill connecting both banks at 270 m depth was targeted (Fig. 17). This sill is flanked by

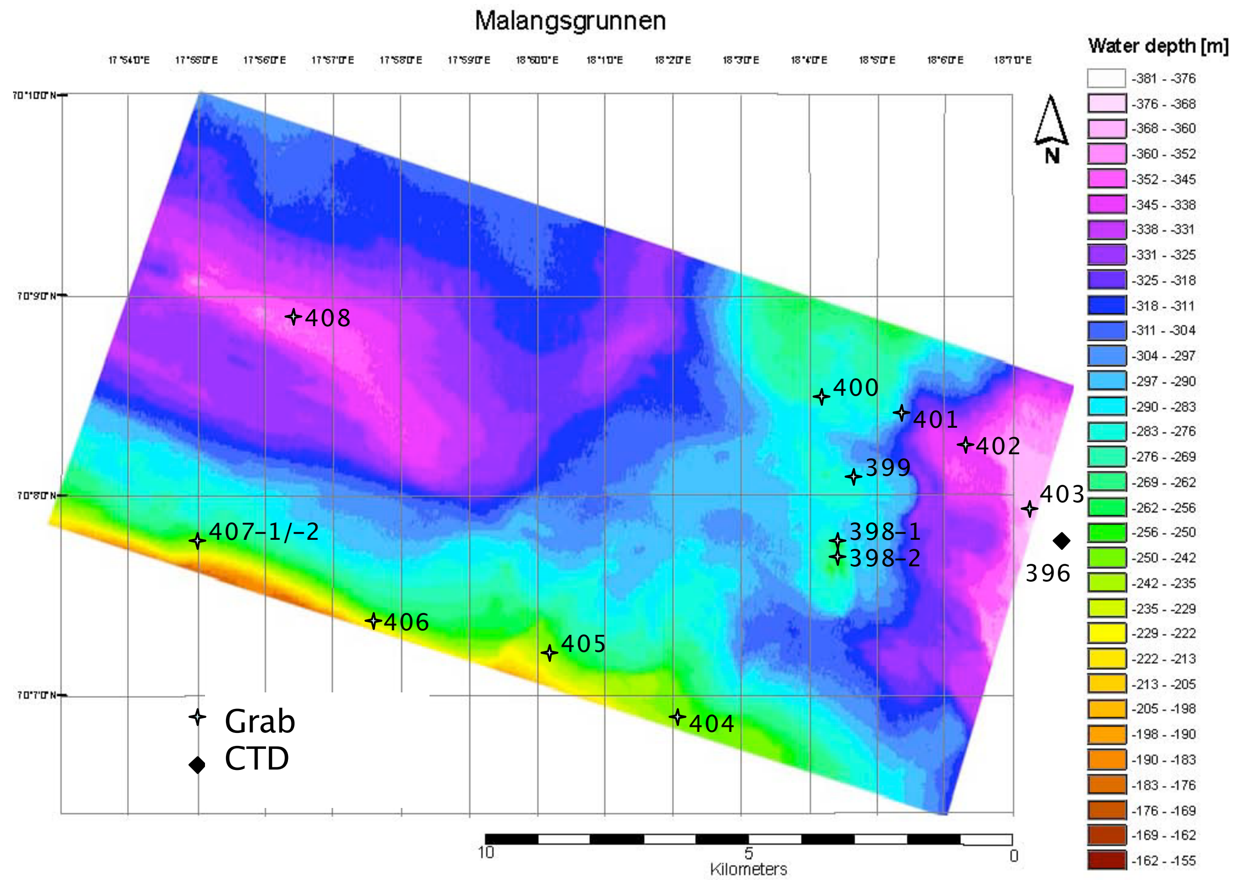

Fig. 17. Mulitbeam map and station in the area off Rebbenesøy.

two shelf troughs with water depths around 360 m. We carried out multibeam mapping (#397, 409), CTD (#396) and grab sampling (#398-408).

Sediments.— Three different sediment facies were encountered in the studied area. The deeper trough sediments consist of fine-grained silts of terrigenous origin, whereas on the sill, a pebbly to boulder-rich lag deposit rests upon siliciclastic sands (Fig. 18A). The epibenthic fauna is rich in ophiuroids, scaphopods and molluscs. Pure carbonate sands were sampled at all stations along the northern rim of Malangsgrunnen Bank. Because of the richness of bryozoans, these deposits represent a characteristic BRYOMOL facies and are imported from the shallow bank area, were the production sites of the bryozoans are known to occur (Fig. 18B).

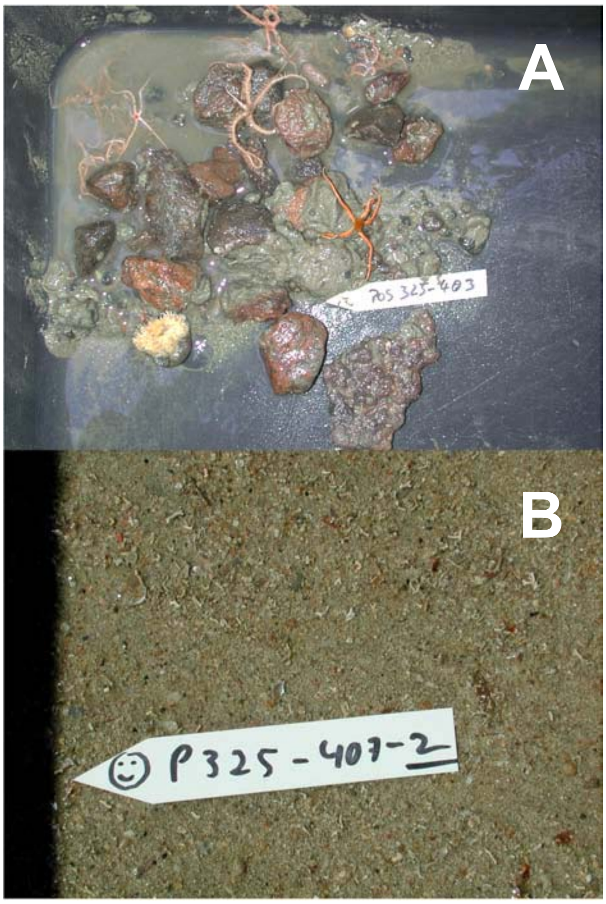

Fig. 18. Contrasting sediments off Rebbenesøy. **A** Pebbly lag deposit rich in ophiuroids are confined to the sill area (see Fig. 17). **B** BRYOMOL sediments are imported from the Malangsgrunnen Bank in the south.

Sotbakken (Nordvestbanken)

Background.— The Sotbakken area was recommended to search for a poorly known coral reef site. An E-W trending trough with water depth of 300 m is accentuated by ridges showing the same strike line. North and south of this trough, shallower banks with water depths around 180 m (Fig. 19).

P325 Activities.— We carried out a small survey including multibeam mapping (#432, 461), CTD (#431), grab sampling (#462-467) and a JAGO dive (#468) (Fig. 19).

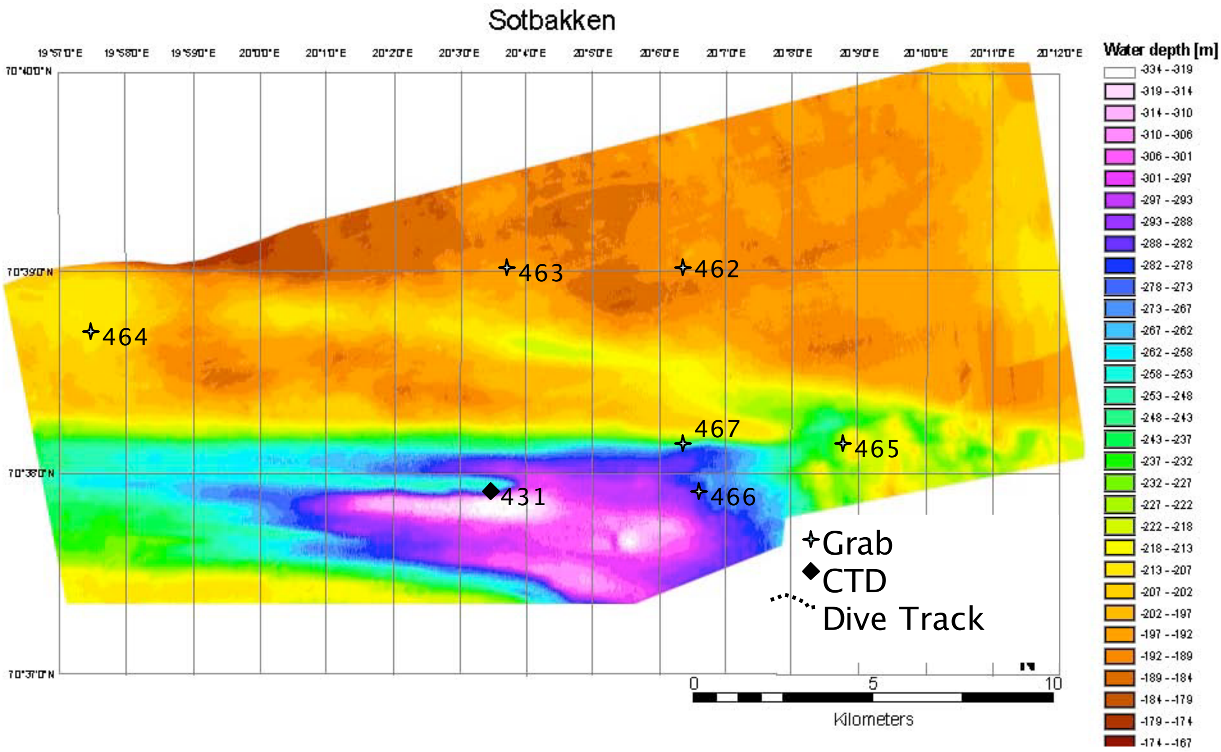

Fig. 19. Multibeam map and stations in the Sotbakken area.

Seabed observations.— The deeper areas with flat seabed consist of a highly bioturbated mud rich in crustaceans and infaunal polychaetes (Fig. 20A). Isolated IRD boulders measuring up to 1 m in size often are found in seabed depressions. These depressions may be the result of the dropping impact of the boulder into the sediment. These structures can be easily mixed with pockmarks. Another observation are alignments of dropstones on the seabed which may indicate a sudden release of debris from a melting iceberg. The dropstones attract a diverse epilithic community dominated by sponges, octocorals and hydroids (Fig. 20B).

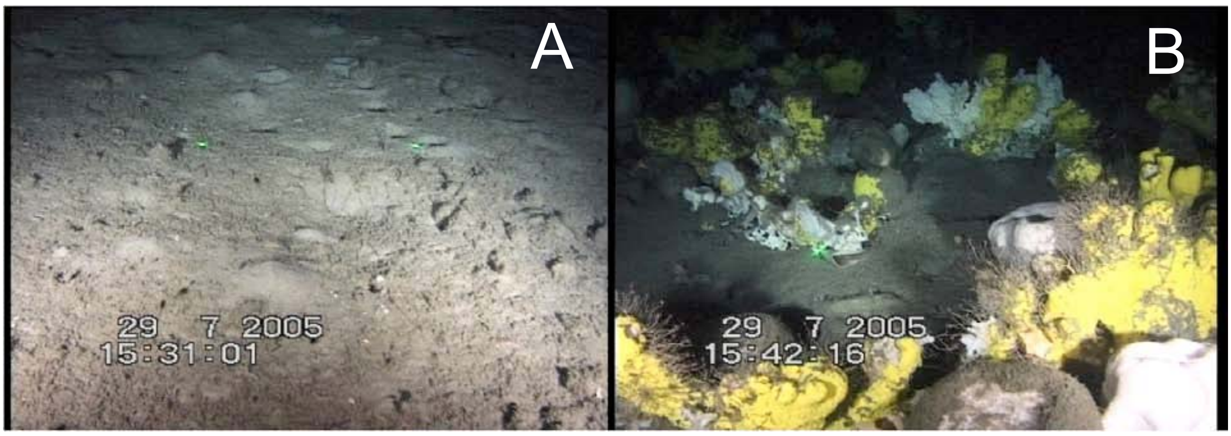

Fig. 20. Seabed impressions from the Sotbakken area. **A** Highly bioturbated sandy mud plain. **B** Alignment of boulder dropstones heavily colonised with sponges and *Tubularia* hydroids (framegrabs from Dive 468).

Stjernsund Reef

Background.— The Stjernsund is a famous coral location of Carl Dons (1932, 1934, 1944) and represents one of the northernmost *Lophelia* reefs (Fig. 21). In 1994, the P.I. carried out a first survey to the Stjernsund reefs with RV JOHAN RUUD. The results were published in Freiwald et al. (1997). The approximately 20 km long sound connects the open sea (Lopphavet, SW Barents Sea) with the Altafjord. The main reef area is confined to a distinct sill at N 17°16 and E022°28 that acts as a barrier against the strong tidal currents flowing consistently from the Lopphavet SE into the Altafjord. The sill crest depths vary between 236 and 203 m and the adjacent troughs are 410 m (western trough) and 480 m (eastern trough) deep (Fig. 22). The sill has an asymmetric cross-section with a gently inclined SE flank and a steep NW flank (Figs. 22, 23). The overall architecture, seabed

Fig. 21. Map of Carl Dons (1944) showing locations of life (black circles) in the Stjernsund and adjacent areas and dead corals (crossed circles).

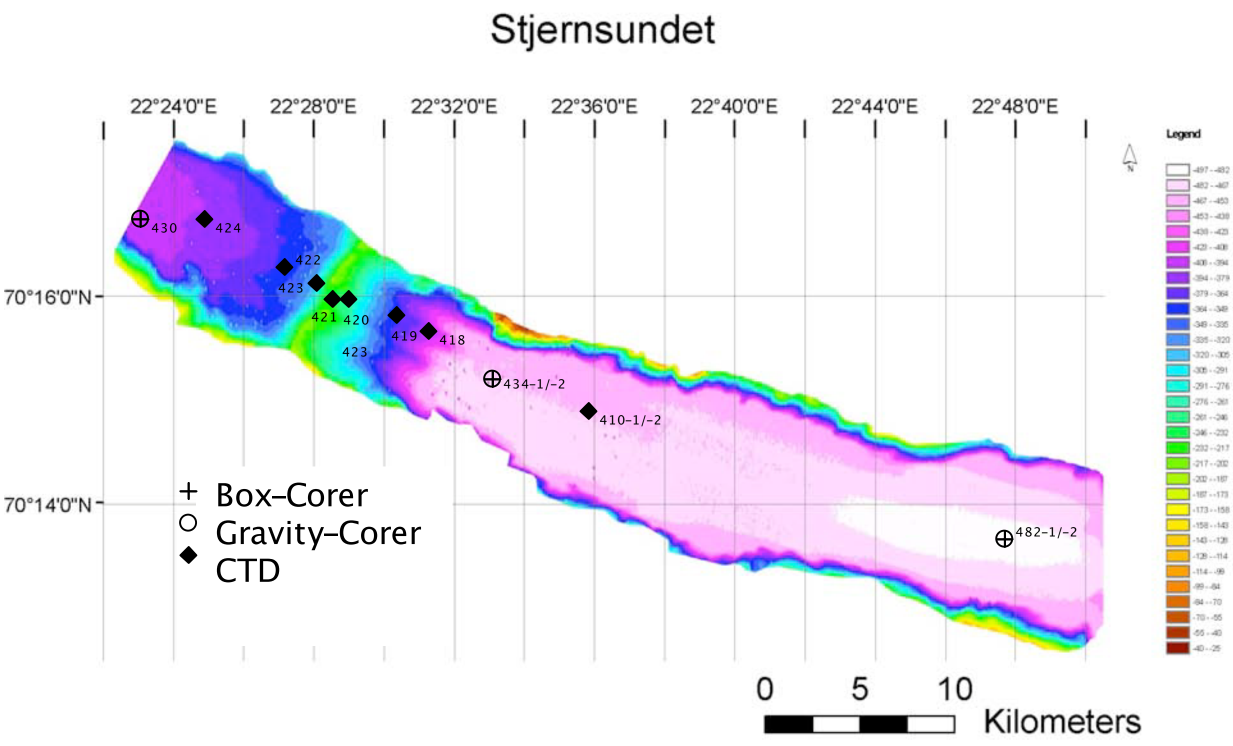

Fig. 22. Multibeam map of the Stjernsund with positions of the box- and gravity-corer transect and some selected CTD stations.

observations and physical properties of the trough sediments point to a morainic origin of the sill with a former glacier advance through the Altafjord. The glacier load has generated the asymmetric shape of the sill and has left behind over-consolidated sediments only in the SE trough.

P325 activities.— The Stjernsund was the major study site of the 2nd leg. In total, we carried out 3 multibeam grids (# 411, 425, 481), 9 JAGO dives (#412, 417, 429, 433, 460, 474, 484-486), 35 CTD casts some of them included water sampling (#410-424, 435-454, 475-480), 7 grab stations (# 413-416, 426-428), 7 box-corer stations (#430-2, 434-1, 455, 456, 482-1) and 11 gravity-corer stations (#430-3, 434-2, 457-459, 470-473, 482-2). The 3-m-long barrel was used only at station #457, otherwise the 6-m-barrel was in operation. First results of the hydrographic measurements are documented in the next chapter).

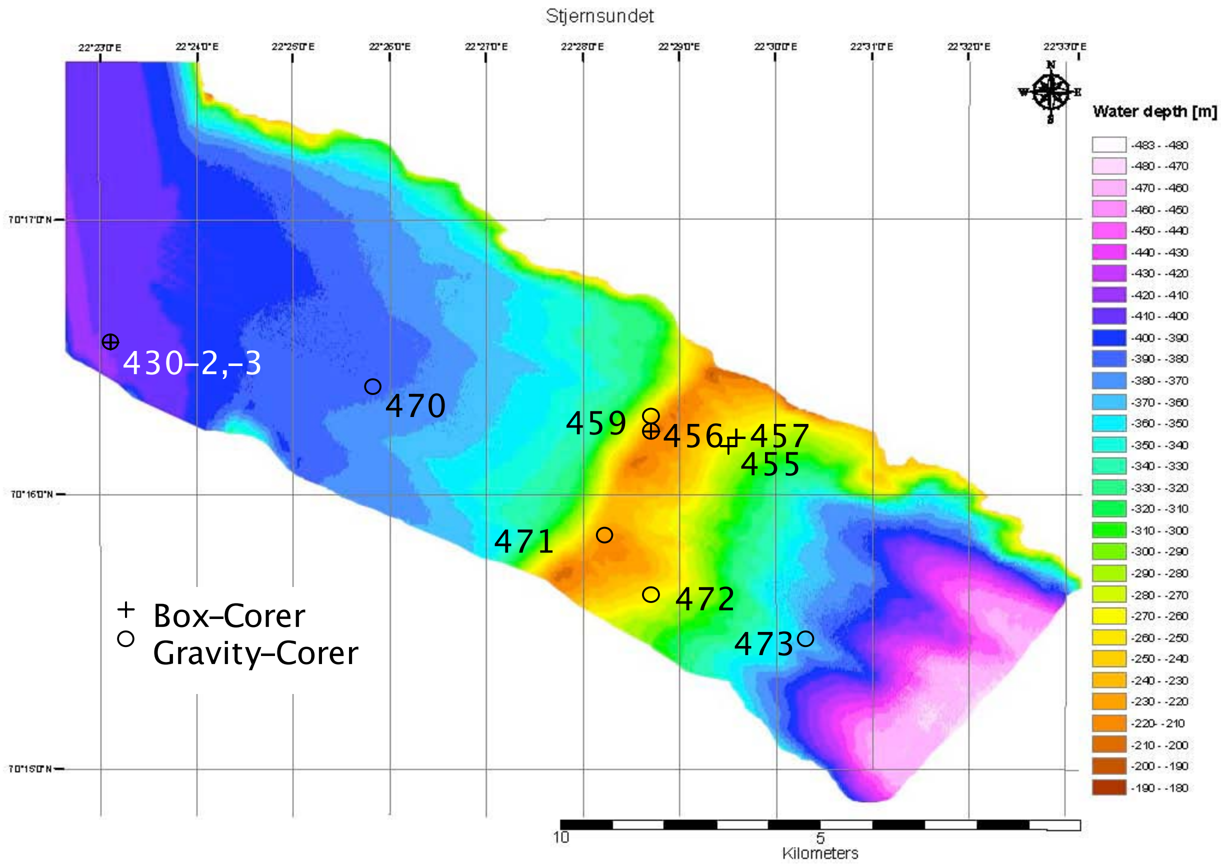

Fig. 23. Close-up of the sill in the Stjernsund showing more box- and gravity-corer stations. Note the asymmetric morphology of the sill.

Sedimentary facies and habitats.— This section provides a brief overview of seabed observations based on box-corer surfaces and JAGO dive documention.

Sedimentary facies and biological habitat variability is described in a logical sequence beginning in the NW trough and continuing over the sill in SE direction and ending up in the SE trough. The surface sediments in the NE trough at 407 m depth consist of 20 cm-thick sand deposits enriched with pebbles, molluscs, benthic foraminifers and few coral fragments (Fig. 24). The surface is highly bioturbated by polychaetes, echiurids, ophiuroids and others. This unit is underlain by a pebbly clay. The contact between both units is mottled through bioturbation. Interestingly, at the

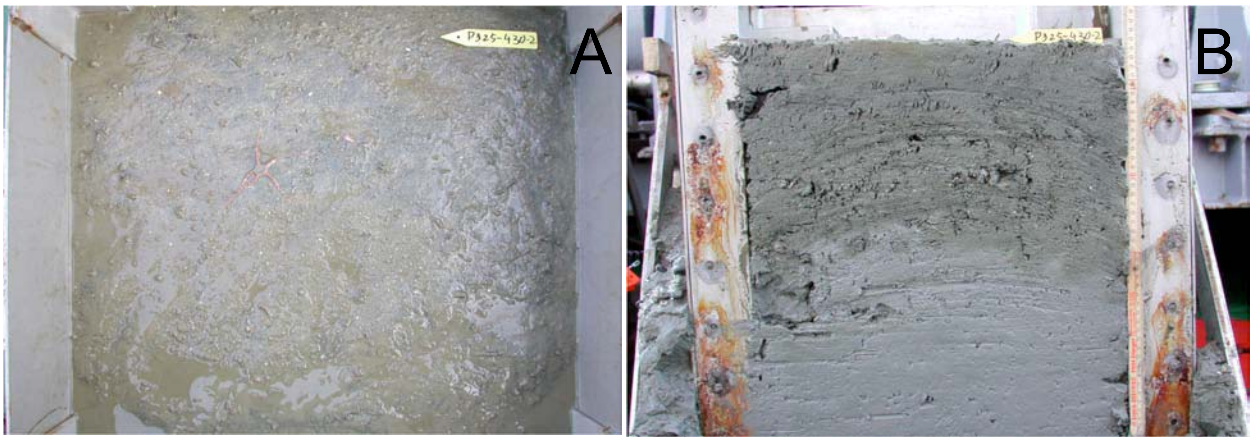

Fig. 24. Box-corer station #430-2, NW Stjernsund trough, 407 m water depth. **A** Bioturbated sediment surface with ophiuroid and polychaete tubes. **B** Profile through the recovered sediment with the 20-cm-thick surface sand unit and the pebbly clay unit at the base.

base of box-corer #430-2, a boulder layer with larger *Lophelia* colony fragments was found. The steep western slope of the Stjernsund sill represents a mosaic of surface sediment types and benthic communities (Fig. 25). Winnowed boulders up to 2 m in diameter or boulder fields were encountered a few times from 365 m upslope (Fig. 25A). Coral rubble is strewn between the boulders which are colonised with sponges (*Geodia, Axinella*), *Paragorgia arborea,* bryozoans, barnacles (*Chirona hameri*) and *Tubularia* hydroids. From 337 m upslope, coral rubble forms up to 20 cm thick pavements which are accentuated by mega-ripples and outwash holes (Fig. 25B-C). At depths deeper than 330 m, the ripple crests are oriented perpendicular to the currents but start to bifurcate in shallower slope environments. The rippled character diminishes at depths shallower than 300 m. The rubble facies often shows dense colonisation of *Protanthea simplex* and *Tubularia* hydroids. *Paragorgia* colonies occur in both colour types (red and white). Larger colonies (generally >1 m) often are fallen to the side as a consequence of the vigorous tidal currents. The sandy sediments underneath the coral rubble pavement is inhabited by *Bonellia viridis*, often in great numbers (Fig. 25C). Isolated *Lophelia* colonies, sometimes up to 1.5 m thick, with spheroidal (cauliflower) growth habit were frequently encountered from 309 m onward (Fig. 25D). Patches of *Capnella/Drifa* alcynonarians and *Geodia-Bolocera* assemblages commonly occur further upslope (Fig. 25E-F). All in all, there is the impression that the thick coral rubble pavement is rather a parautochthonous unit than an entirely allochthonous one. If this conclusion can be substantiated, it implies that the ecological conditions for *Lophelia* became more and more deteriorated while present-day conditions preferably support proliferating growth on the crest of the Stjernsund sill.

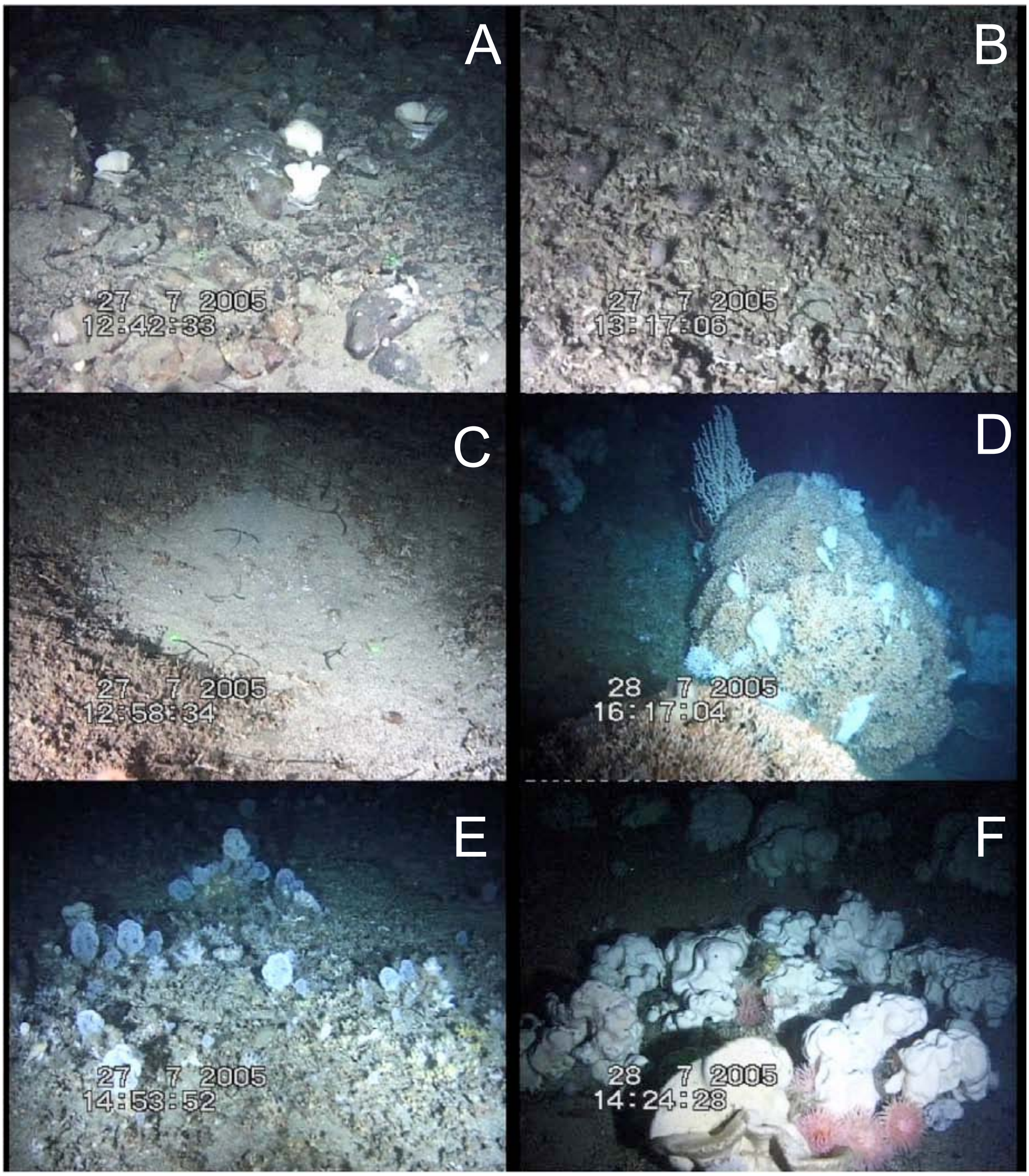

Fig. 25. The steep western slope of Stjernsund sill. **A** Winnowed boulders of the moraine basement with *Phakellia* sponges. **B** Coral rubble pavement with *Protanthea simplex* actinans. **C** Outwash holes within the coral rubble showing *Bonellia viridis* living in the sand unit underneath. **D** Isolated cauliflower-shaped colony of *Lophelia pertusa*. **E** Coral rubble pavement with *Capnella/Drifa* alcyonarians. **F** Accumulation of *Geodia, Pachastrella* and *Bolocera tuediae* (Framegrabs from Dive #433 (A-C, E) and #460 (D, F).

The sill crest from about 260 to 200 m depth strikes in NE-SW direction over a distance of c.1 km. Two large *Lophelia* reef complexes were documented in this area, each measuring about 400 m across and up to 100 m wide (Fig. 26). A gap of 90 m in the central part of the sill separates the two reef complexes. The shape of the individual reefs in each complex shows indications of strong hydrodynamic control. The reefs are oriented parallel to the currents with a maximum thickness of 2-8 m on average. The offreef-reef transition is very sudden and the live corals grow over the rubble aprons (Fig. 27). In the Stjernsund area, two soft tissue colourmorphs of *Lophelia* occur, an orange morph and a white one (with translucient soft tissue; Fig. 28A). Mostly one colourmorph dominates over the other in the reefs or large colonies with the orange one as the by far most the abundant (Fig. 28B-C). The coral growth forms are peculiar and have been described in detail by Freiwald et al. (1997) as tubular, stout-and-crowded, and stereome-thickened. The tubular (trumpet-shaped with very thin theca) growth form is the most abundant one (see Fig. 28A, D, H). The living outer zone of the corals seems to live in competition for space with *Paragorgia arborea* (Fig. 28B) and especially *Mycale lingua* (Fig. 28C, H). The reefless gap on the central sill is covered by coral rubble

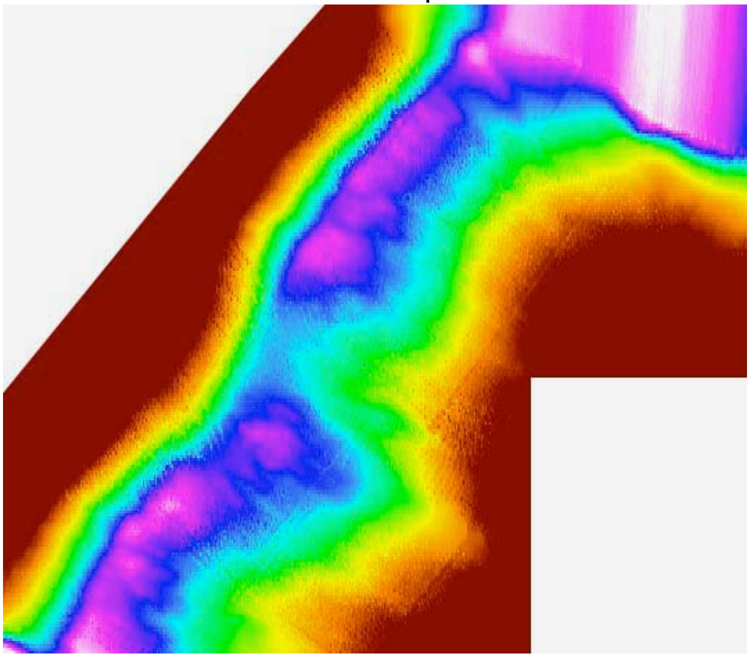

Fig. 26. Modified map of the Stjernsund reef complexes (in deep blue and pink colour codes).

Fig. 27. Sharp transition reef versus offreef on the Stjernsund sill (Dive #484). *Mycale* sponges compete with *Lophelia.*

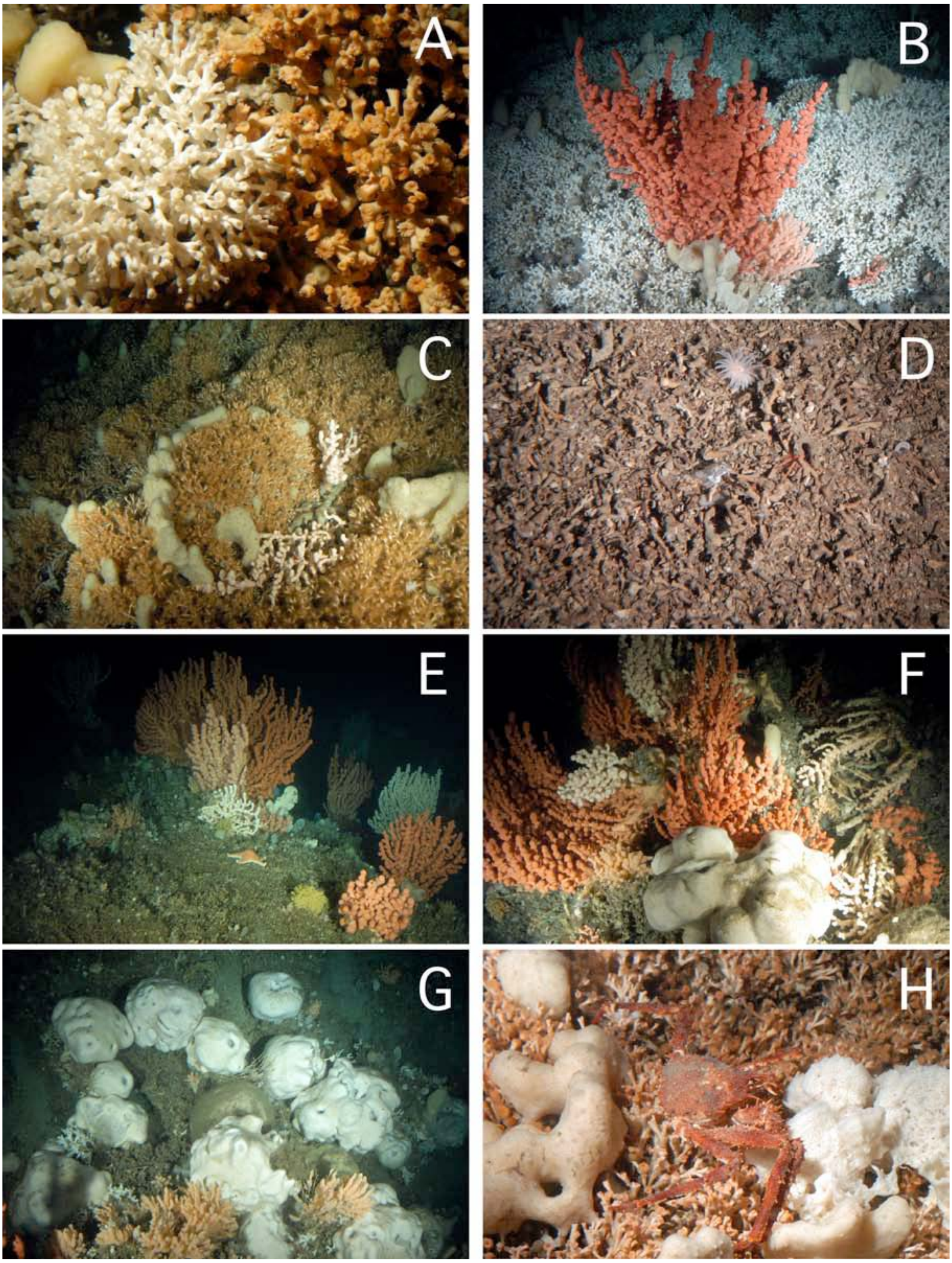

Fig. 28. The Stjernsund reefs. **A** The two colourmorphs of *Lophelia*. **B** Red *Paragorgia* in between a coral reef. **C** *Mycale lingua* and white *Paragorgia* compete with *Lophelia* for space. **D** Coral rubble of the trumpet-shaped growth form. **E** and **F** *Paragorgia* forests. **G** *Geodia* accumulation with *Primnoa resedaeformis*. **H** *Lithodes maja* walking over *Lophelia* and between the sponges. Dives #474 (A, H) and #484 (B-G).

(Fig. 28D), *Paragorgia*-dominated forests that grow on dead coral colonies (Fig. 28E-F), and *Geodia* accumulations (Fig. 28G). The more gently inclined eastern flank of the sill is much more homogenously covered by coral rubble pavements with features similar to the western flank. Living corals only occur as isolated patches (Fig. 29A). Winnowed boulders were not observed. At 472 m depth, the sediment is still sand-dominated and very rich in tube-forming polychaetes (probably sabellarids) but difficult to penetrate because of over-consolidated clays (due to the glacier load, Fig. 29B). We found a small corable microbasin within the eastern trough at 478 m depth. Here, the sediment consists of a soupy silty-clay with two faint layers of coral rubble (Fig. 29C-D).

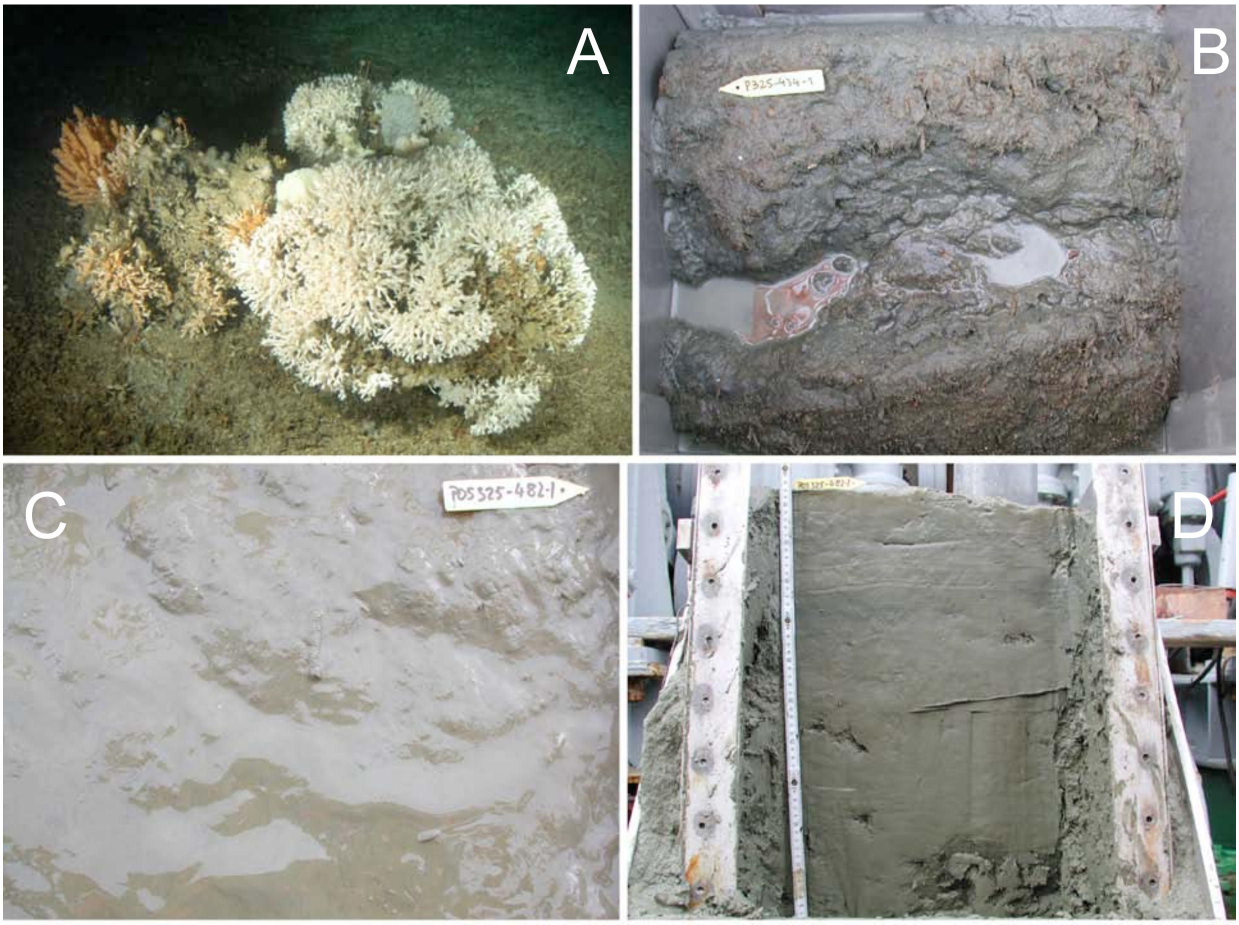

Fig. 29. The eastern slope of Stjernsund sill. **A** Isolated *Lophelia* patch with the two colourmorphs, *Capnella/Drifa, Primnoa* and *Tubularia* (Dive #412). **B** Sediment surface of box-corer #434-1 at 472 m depth. **C** Soupy sediment surface of box-corer #482-1 at 478 m depth. **D** Sediment profile of box-corer #482-1.

Hydrography: first results

The overall performance of the CTD was very good. Downcast measurements were used for further processing of data using software SBE Data Processing Version 5.30a (ftp://ftp.halcyon.com/pub/seabird/out) and Ocean Data View mp-Version 2.0 (http://www.awi-bremerhaven.de/GEO/ODV) for visualisation. Table 7 summarizes the log sheets for the individual CTD casts. Water samples were taken at stations 3–4 m above seafloor (bottom alarm) and 13–15 m above seafloor for stable oxygen isotope, dissolved inorganic carbon (DIC) and Sr isotope analyses.

The main water masses along the Norwegian coast from 66°N to 71°N are of coastal and Atlantic origin. Norwegian Coastal Water (NCW) has salinities less than 35 PSU and stretches like a wedge out over the shelf edge merging with Atlantic Water (AW, Skardhamar & Svendsen 2005). In our study, an increase in thickness of the Norwegian Coastal Water from 50 m to 250 m corresponds with an increase in latitude from south to north (Fig. 30). AW is characterised by salinities above 35 PSU and is present below the low-saline NCW in water depth of >50–250 m. Norwegian Sea Deep Water (NSDW), with salinities below 34.95 PSU and temperatures less than 0°C, fills the deep basins below 800 m water depth (Fig. 30).

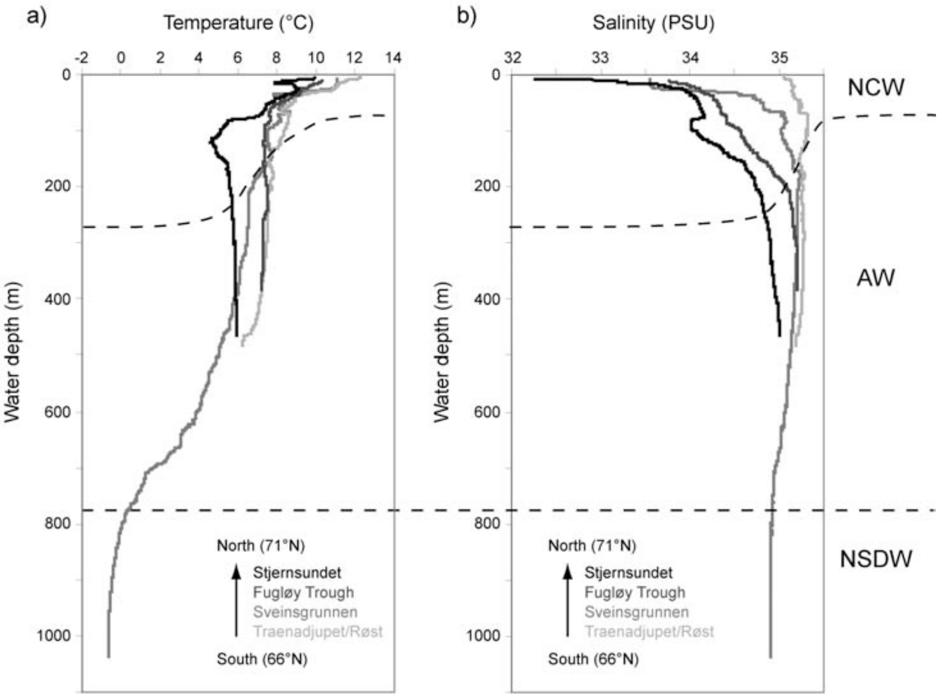

Fig. 30. A Temperature and **B** salinity profiles of Traenadjupet/Røst (light grey), Sveinsgrunnen (grey), Fugløy Trough (dark grey), and Stjernsundet (black) indicate an increasing thickness of the Norwegian Coastal Water between 50 and 250 m with increasing latitude (from south to north). The depth of cold-water coral reef occurrences corresponds to 250 to 300 m. NCW = Norwegian Coastal Water, AW = Atlantic Water, NSDW = Norwegian Sea Deep Water.

The hydrographic profiles across the shelf of Sveinsgrunnen from 200 to >1000 m water depth is illustrated in Figure 31. Salinity values show an increase from 33.5 to 35 PSU within the first 200 m and decrease to values below 35 PSU below 600 m water depth indicating the presence of AW with a maximum in salinity between 200 and 600 m. Below 600–800 m NSDW fills the basin as indicated by low temperatures and low salinities. Dissolved oxygen shows increasing values with depth but decreasing values of the surface layer with increasing distance from the coast. The pronounced oxygen maximum at ~600 m water depth occurs at the deeper shelf slope at the water mass boundary between AW and NSDW (Fig. 31).

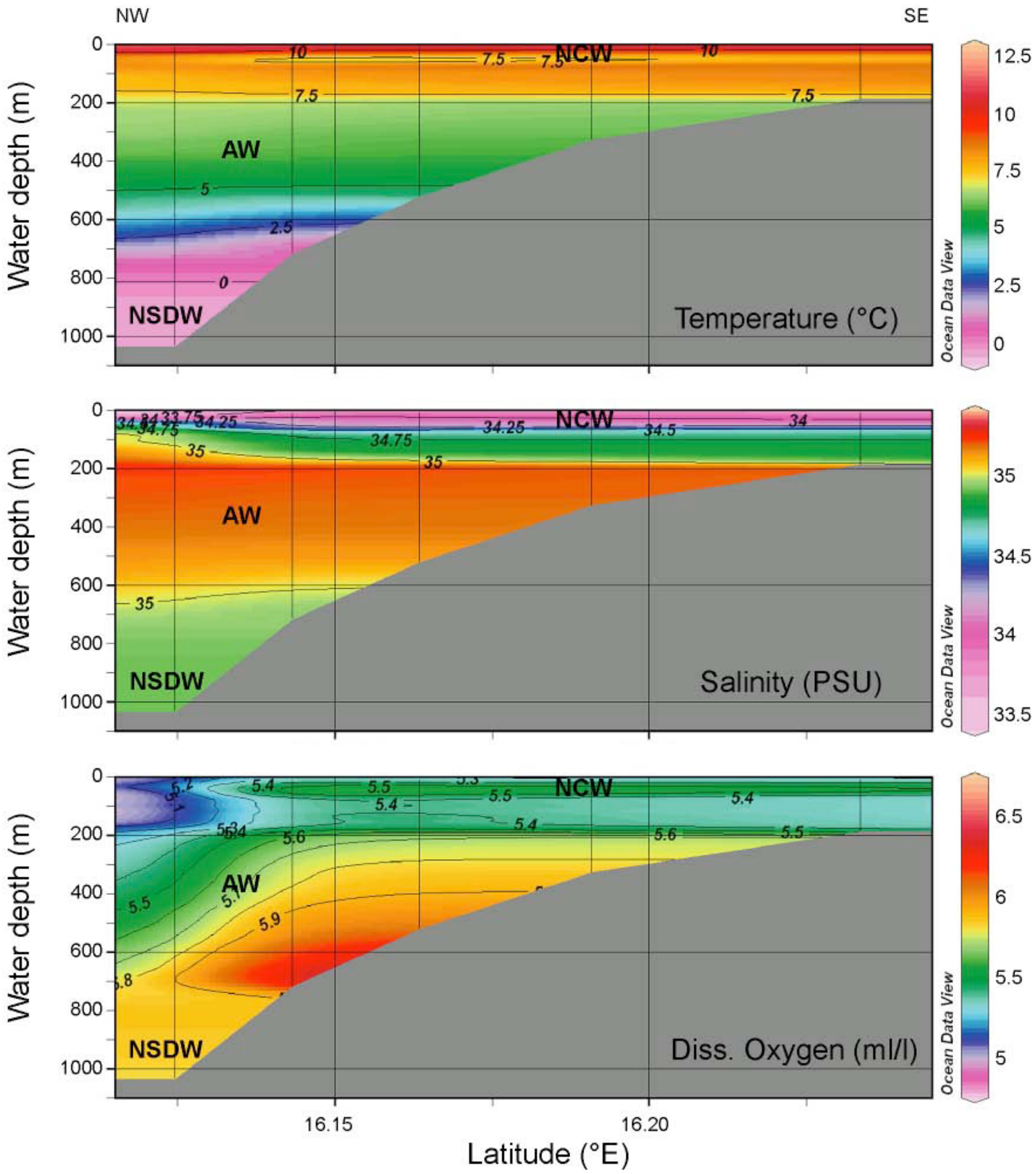

Fig. 31. Temperature, salinity and dissolved oxygen profiles across the continental slope at Sveinsgrunnen. NCW = Norwegian Coastal Water, AW = Atlantic Water, NSDW = Norwegian Sea Deep Water. Note: Dissolved Oxygen values are not calibrated but downcast profiles are considered to represent true variability of seawater's dissolved oxygen.

Main investigation concentrated on the coral occurrences on the Stjernsund sill. A cross section across the sill is illustrated in Figure 32, indicating the variability of temperature, salinity and dissolved oxygen. Norwegian Coastal Water with salinities <35 PSU occupies the complete water column east of the sill, while Atlantic Water occurs below ~250 m west of the sill. Dissolved oxygen shows the highest variability with maximum values >5.8 ml/l at the western surface and forming a well-pronounced body between 50 and 150m thinning out towards the east (Fig. 32).

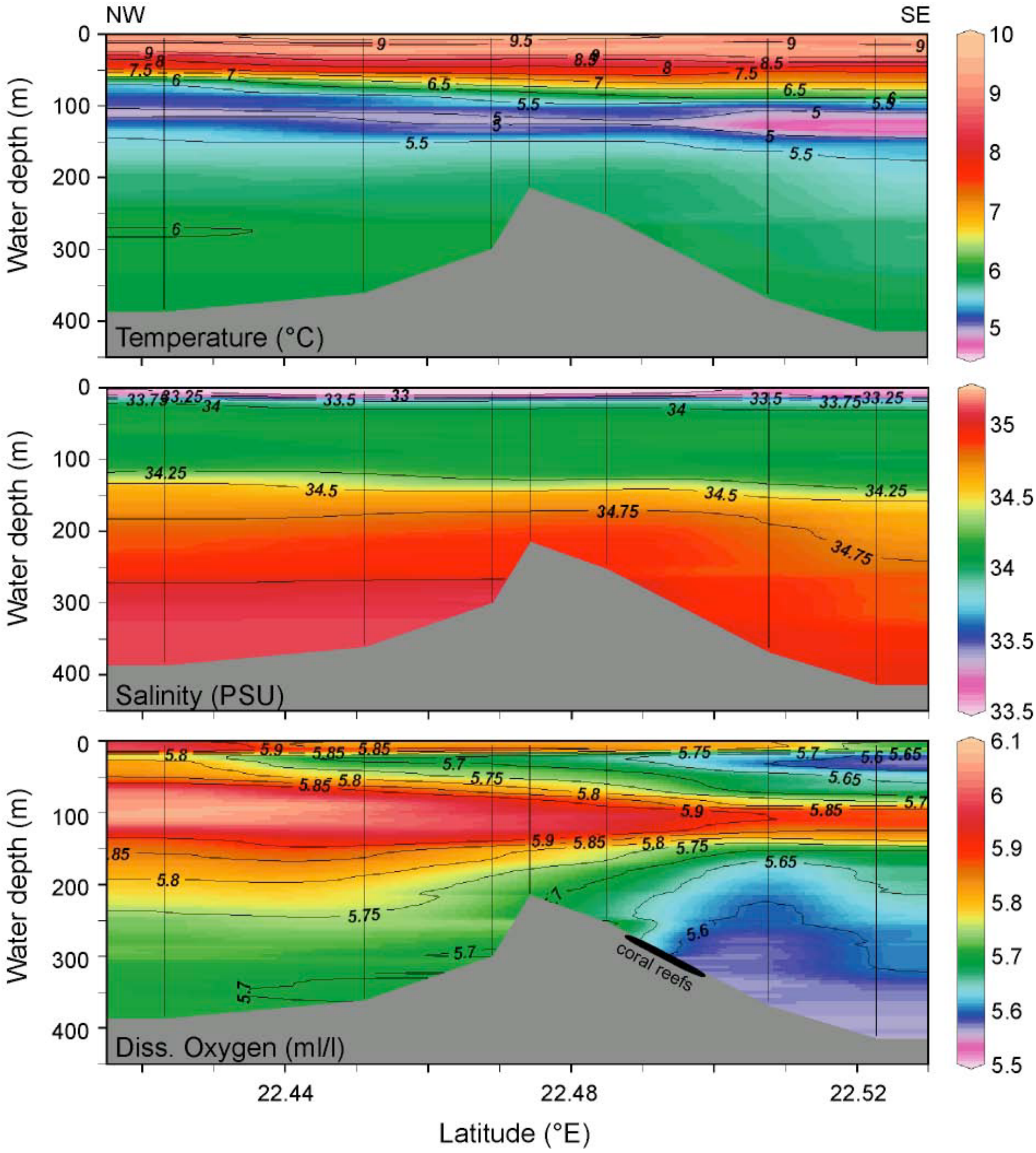

Fig. 32. Profiles of temperature, salinity and dissolved oxygen across Stjernsund sill. Coral occurrence is indicated on the eastern flank of the sill, where dissolved oxygen shows minimum values.

Minimum oxygen values of <5.6 ml/l occur east of the sill below 200 m where coral reefs were localized and investigated using submersible JAGO (Fig. 32). This pattern seems to determine previous observations of locally enhanced oxygen consumption by the dense coral ecosystem (Rüggeberg et al. 2005). However, a temporal variability of the tidal influence may overprint the graphic illustration of this cross-section, due to the temporal offset (30 to 60 minutes) between each station. Therefore, 10 CTD stations each were performed east and west of the sill covering a complete tidal cycle (13 h) to determine the temporal variability of the investigated hydrographic parameters (Figs. 33, 34).

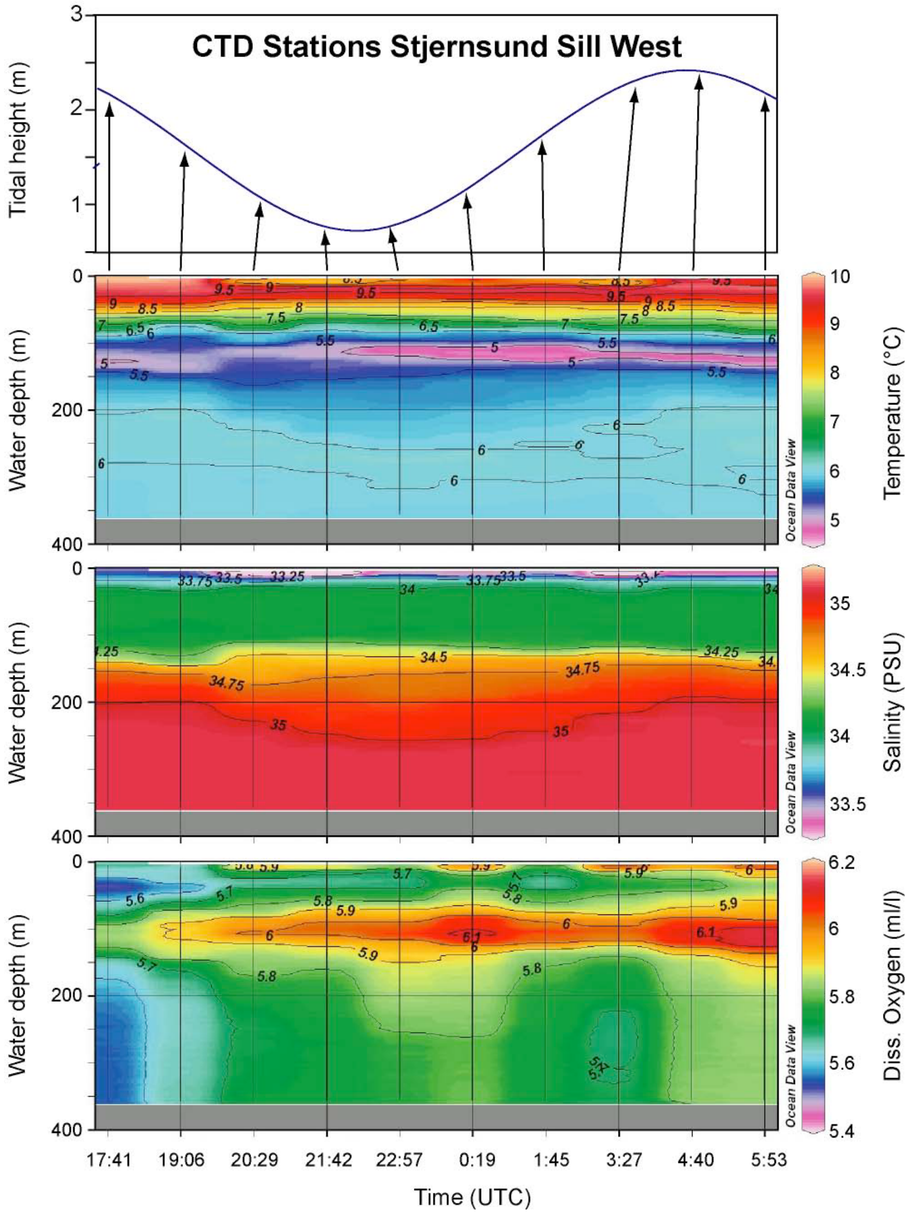

Fig. 33. Temporal variability of temperature, salinity and dissolved oxygen at western position of Stjernsund sill (70°16.39’N, 022°27.2’E). Start of acquisition: 27th July 2005, 17:41 h; end of acquisition: 28th July 2005, 5:53 h. Tidal height forecast for Tromsø (69°39’N, 018°58’E).

Temperature and Salinity seem to follow the tidal cycle (Figs. 33, 34). During tidal low stand (22–23 h UTC) the temperature minimum layer between 100 and 150 m water depth is shallower compared to tidal high stands (16–17 h UTC and 4–5 h UTC) at both sides of the sill. The thickness of Norwegian Coastal Water at the western side of the sill shows a deeper distribution during tidal low stand (upper 35 PSU limit at

250 m compared to high stands 200 m water depth, Figure 33). At the eastern side of the sill Atlantic Water (>35 PSU) is only present during tidal high stands below 350 m water depth and seems to be repressed during tidal low stand (Fig. 34). This result indicates a tidally steered flow over the sill of Atlantic Water from west to east during tidal high stands.

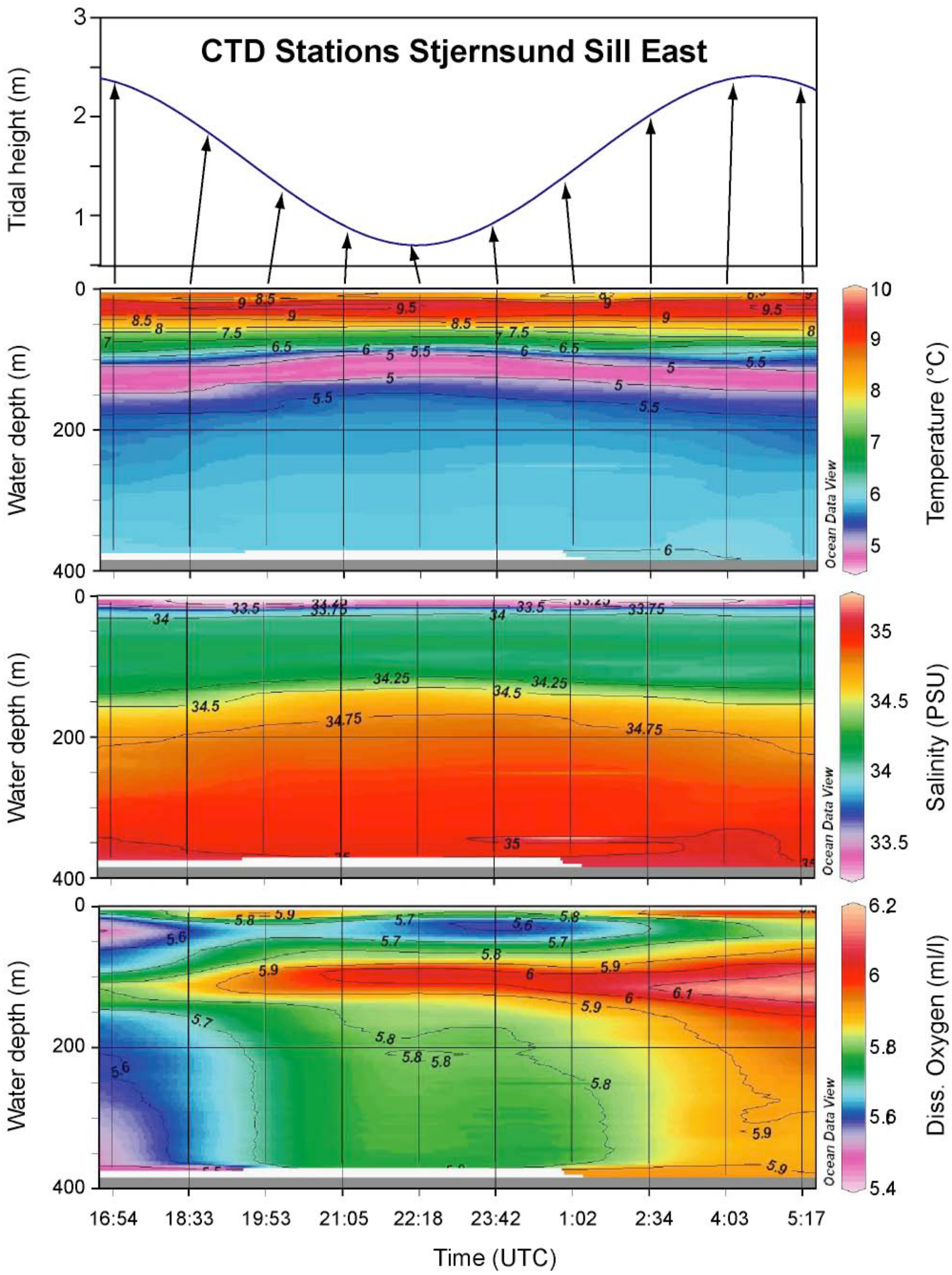

Fig. 34. Temporal variability of temperature, salinity and dissolved oxygen at eastern position of Stjernsund sill (70°16.39'N, 022°27.2'E). Start of acquisition: 27th July 2005, 16:54 h; end of acquisition: 28th July 2005, 5:17 h. Tidal height forecast for Tromsø (69°39'N, 018°58'E).

Maximum values of dissolved oxygen with >5.9 ml/l follow the cold layer between 100 and 150 m water depth (Figs. 33, 34). At the beginning of the acquisition (high stand) dissolved oxygen shows minimum values and increases continuously to tidal low stand at both sides of the sill (Figs. 33, 34). However, maximum values occur in all depths during high stand at the end of acquisition at both sides. This probably implies a difference in oxygen distribution between two tidal high stands and/or between day and night, which can be only determined running a CTD time series covering at least two fully tidal cycles.

Table 7. Information on all CTD casts during POS 325 including area description and water samples.

Station #	Area	Date	Time (UTC)	Coordinates Lat (°N)	Long (°E)	Depth (m)	Observations, recovery Bottle #	Depth (m)	Temp. (°C)	Sal. (PSU)	Oxy. (ml/l)*	Sr-Isotpe Sample #	$\delta^{18}O/\delta^{13}DIC$ Sample #	Bacteria Sample #
338	Trænadjupet Reefs	16.07.05	5:52	66°53.500'	11°07.470'	379	1	375	7.156	35.246	—	1	338-1	–
							2	364	7.154	35.246	—	2	338-2	–
							3	51	7.88	35.113	—	3	338-3	–
							4	11	12.749	34.832	—	4	338-4	–
354	Trænadjupet Reefs	16.07.05	22:43	66°58.150'	11°07.275'	315	1	315	7.242	35.239	—	5	354-1	–
							2	304	7.24	35.238	—	6	354-2	–
360	Trænadjupet Reefs	17.07.05	14:58	66°58.383'	11°06.539'	299	1	297	7.244	35.241	—	7	360-1	3012
							4	386	7.243	35.241	—	8	360-2	–
362	Trænadjupet Reefs	17.07.05	21:16	67°10.134'	09°18.532'	479	1	478	6.212	35.181	—	9	362-1	–
							2	467	6.268	35.188	—	10	362-2	–
							3	439	6.888	35.232	—	11	362-3	–
373	Røst Reef	19.07.05	14:44	67°31.510'	09°29.402'	315	1	310	7.071	35.245	5.7	12	373-1	–
							2	298	7.064	35.245	5.68	13	373-2	–
374	Røst Reef	19.07.05	15:24	67°31.604'	09°29.599'	316	1	315	7.073	35.245	5.75	14	374-1	–
							2	304	7.069	35.245	5.75	15	374-2	–
375	Røst Reef	19.07.05	16:00	67°31.664'	09°29.825'	308	1	304	7.084	35.246	5.88	16	375-1	–
							2	292	7.099	35.248	5.88	17	375-2	–
376-1	Røst Reef	19.07.05	16:39	67°31.752'	09°30.155'	330	1	319	7.09	35.247	5.83	18	376/1-1	3013
							2	306	7.096	35.247	5.83	–	–	–
376-2	Røst Reef	19.07.05	17:12	67°31.774'	09°30.209'	329	1	318	7.07	35.245	5.78	19	376/2-1	–
							2	307	7.07	35.245	5.75	20	376/2-2	–
377	Røst Reef	19.07.05	17:50	67°31.812'	09°30.309'	346	1	331	7.059	35.244	5.77	21	377-1	–
							2	320	7.065	35.244	5.75	22	377-2	–
378	Røst Reef	19.07.05	18:31	67°31.583'	09°30.398'	271	1	265	7.102	35.248	5.73	23	378-1	–
							2	254	7.104	35.248	5.73	24	378-2	–
379	Røst Reef	19.07.05	19:07	67°31.653'	09°30.162'	320	1	305	7.037	35.242	5.74	25	379-1	–
							2	294	7.038	35.243	5.75	26	379-2	–
380	Røst Reef	19.07.05	19:42	67°31.768'	09°29.802'	323	1	322	6.997	35.239	5.7	27	380-1	–
							2	311	6.993	35.239	5.68	28	380-2	–
381	Røst Reef	19.07.05	20:46	67°31.883'	09°29.477'	338	1	336	6.97	35.237	5.71	29	381-1	–
							11	324	6.972	35.238	5.69	30	381-2	–
383	Sveinsgrunnen	21.07.05	22:44	69°43.009'	16°07.477'	1040	1	1039	-0.623	34.91	5.75	–	383-1	–
							2	593	4.1	35.081	5.3	31	383-2	–
							3	298	6.445	35.202	5.18	32	383-3	–
386	Sveinsgrunnen	22.07.05	7:20	69°42.457'	16°14.020'	188	1	188	7.143	34.954	5.38	33	386-1	–
							2	175	7.45	34.841	5.3	34	386-2	–
							3	50	7.004	34.088	5.52	35	386-3	–
							4	10	11.254	33.61	5.39	36	386-4	–
393	Sveinsgrunnen	22.07.05	12:54	69°42.687'	16°11.452'	323	–	–	–	–	–	–	–	–
394	Sveinsgrunnen	22.07.05	13:44	69°42.824'	16°09.812'	523	–	–	–	–	–	–	–	–
395	Sveinsgrunnen	22.07.05	14:38	69°42.950'	16°08.602'	718	–	–	–	–	–	–	–	–
396	Fugløyrinne	22.07.2005	20:16	70°07.743'	18°07.976'	383	1	383	7.219	35.2	5.74	37	396-1	–
							2	371	7.222	35.199	5.73	38	396-2	–

Station #	Area	Date	Time (UTC)	Coordinates Lat (°N)	Long (°E)	Depth (m)	Observations, recovery Bottle #	Depth (m)	Temp. (°C)	Sal. (PSU)	Oxy. (ml/l)*	Sr-Isotpe Sample #	$\delta^{18}O/\delta^{13}DIC$ Sample #	Bacteria Sample #
410	Stjernsund 450m - E	25.07.05	3:15	70°14.927'	22°35.496'	467	1	464	5.926	35.011	5.41	39	410-1	–
							2	453	5.882	34.967	5.41	40	410-2	–
418	Stjernsund 400m - E	25.07.05	17:33	70°15.507'	22°31.370'	420	1	411	5.875	34.968	5.55	41	418-1	–
							2	401	5.875	34.962	5.53	42	418-2	–
419	Stjernsund 370m - E	25.07.05	18:30	70°15.741'	22°31.463'	369	1	363	5.867	34.96	5.56	43	419-1	–
							2	350	5.867	34.961	5.54	44	419-2	–
420	Stjernsund 270m - E	25.07.05	19:09	70°16.004'	22°29.108'	253	1	247	5.821	34.918	5.61	45	420-1	3014
							2	247	5.821	34.918	5.61	45	420-1	3015
							3	237	5.803	34.91	5.6	46	420-2	–
421	Stjernsund 200m - T	25.07.05	19:42	70°16.096'	22°28.458'	210	1	213	5.884	34.943	5.65	47	421-1	–
							2	203	5.783	34.885	5.63	48	421-2	–
422	Stjernsund 300m - W	25.07.05	20:17	70°16.184'	22°28.145'	298	1	300	5.987	35.085	5.66	49	422-1	–
							2	289	5.984	35.072	5.65	50	422-2	–
423	Stjernsund 370m - W	25.07.05	20:55	70°16.363'	22°27.066'	362	1	359	5.909	35.094	5.68	51	423-1	–
							2	349	5.911	35.093	5.66	52	423-2	–
424	Stjernsund 380m - W	25.07.05	21:40	70°16.646'	22°25.397'	388	1	384	5.904	35.096	5.7	53	424-1	–
							2	374	5.904	35.095	5.68	54	424-2	–
410-2	Stjernsund 470m - W	25.07.05	22:47	70°14.857'	22°34.977'	467	1	463	5.956	35.006	5.75	55	410/2-1	–
							2	455	5.955	35.005	5.74	56	410/2-2	–
435	Stjernsund T01 east	27.07.05	16:54	70°15.770'	22°30.643'	375	–	–	–	–	–	–	–	–
436	Stjernsund T01 west	27.07.05	17:41	70°16.378'	22°27.244'	364	–	–	–	–	–	–	–	–
437	Stjernsund T02 east	27.07.05	18:33	70°15.731'	22°30.501'	374	–	–	–	–	–	–	–	–
438	Stjernsund T02 west	27.07.05	19:06	70°16.392'	22°27.198'	362	–	–	–	–	–	–	–	–
439	Stjernsund T03 east	27.07.05	19:53	70°15.744'	22°30.489'	374	–	–	–	–	–	–	–	–
440	Stjernsund T03 west	27.07.05	20:29	70°16.409'	22°27.207'	362	–	–	–	–	–	–	–	–
441	Stjernsund T04 east	27.07.05	21:05	70°15.732'	22°30.465'	367	–	–	–	–	–	–	–	–
442	Stjernsund T04 west	27.07.05	21:42	70°16.389'	22°27.231'	361	–	–	–	–	–	–	–	–
443	Stjernsund T05 east	27.07.05	22:18	70°15.740'	22°30.596'	371	–	–	–	–	–	–	–	–
444	Stjernsund T05 west	27.07.05	22:57	70°16.385'	22°27.176'	361	–	–	–	–	–	–	–	–
445	Stjernsund T06 east	27.07.05	23:42	70°15.731'	22°30.486'	366	–	–	–	–	–	–	–	–
446	Stjernsund T06 west	28.07.05	0:19	70°16.370'	22°27.203'	360	–	–	–	–	–	–	–	–
447	Stjernsund T07 east	28.07.05	1:02	70°15.702'	22°30.521'	368	–	–	–	–	–	–	–	–
448	Stjernsund T07 west	28.07.05	1:45	70°16.398'	22°27.193'	361	–	–	–	–	–	–	–	–
449	Stjernsund T08 east	28.07.05	2:34	70°15.714'	22°30.503'	370	–	–	–	–	–	–	–	–
450	Stjernsund T08 west	28.07.05	3:27	70°16.423'	22°27.214'	362	–	–	–	–	–	–	–	–
451	Stjernsund T09 east	28.07.05	4:03	70°15.643'	22°30.811'	378	–	–	–	–	–	–	–	–
452	Stjernsund T09 west	28.07.05	4:40	70°16.365'	22°27.309'	359	–	–	–	–	–	–	–	–
453	Stjernsund T10 east	28.07.05	5:17	70°15.827'	22°30.734'	383	–	–	–	–	–	–	–	–
454	Stjernsund T10 west	28.07.05	5:53	70°16.330'	22°27.158'	363	–	–	–	–	–	–	–	–
475	Stjernsund Sill	30.07.05	17:24	70°15.555'	22°27.565'	211	–	–	–	–	–	–	–	–
476	Stjernsund Sill	30.07.05	17:56	70°16.062'	22°27.366'	223	–	–	–	–	–	–	–	–
477	Stjernsund Sill	30.07.05	18:29	70°16.417'	22°28.966'	264	–	–	–	–	–	–	–	–
478	Stjernsund Sill	30.07.05	19:00	70°15.726'	22°27.838'	210	–	–	–	–	–	–	–	–
479	Stjernsund Sill	30.07.05	19:30	70°16.258'	22°28.658'	250	–	–	–	–	–	–	–	–
480	Stjernsund Sill	30.07.05	20:16	70°15.890'	22°28.238'	232	–	–	–	–	–	–	–	–

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Stationlist Cruise POSEIDON 325 (Bremerhaven - Tromsø, 12.07. - 03. 08. 2005)

Station No.	Gear	Area	Date	Coordinates				Observations, recovery
				Time (UTC)	Lat. (°N)	Long. (°E)	Depth (m)	
338	CTD	Traenadjupet	16.07.2005	5:52	66°53.50	11°07.47	379	4 bottles (375m, 364m, 51m, 11m)
339	MB			7:54	66°53.17	11°07.16	328	line start
				8:07	66°54.19	11°08.90	379	line end
340-1	MB			8:40	66°58.50	11°07.84	309	start
				8:51	66°58.09	11°05.37	299	end
340-2	MB			9:14	66°58.02	11°05.42	301	start
				9:26	66°58.43	11°07.92	315	end
340-3	MB			9:29	66°58.36	11°07.98	318	start
				9:41	66°57.96	11°05.49	302	end
340-4	MB			9:45	66°57.89	11°05.57	301	start
				9:57	66°58.29	11°08.06	323	end
340-5	MB			10:01	66°58.21	11°08.14	301	start
				10:14	66°57.81	11°05.65	301	end
340-6	MB			10:17	66°57.74	11°05.73	300	start
				10:28	66°58.14	11°08.22	300	end
340-7	MB			10:31	66°58.07	11°08.29	325	start
				10:42	66°57.66	11°05.81	302	end
341	JAGO			11:43	66°58.10	11°07.40	318	start of dive 901
				15:03	66°58.20	11°07.20	315	end of dive 901
342	BG			17:05	66°58.07	11°07.93	314	pebbly sand
343-1	BG			17:29	66°58.14	11°07.90	322	live coral
343-2	BG			17:41	66°58.17	11°07.74	322	pebbly sand, sponges
344	BG			18:08	66°58.14	11°07.79	313	pebbly sand, coral rubble
345	BG			18:28	66°58.12	11°07.73	322	failed
346	BG			18:58	66°58.18	11°07.74	322	pebbly sand
347	BG			19:34	66°58.25	11°07.59	321	pebbly sand
348	BG			19:55	66°58.28	11°07.61	321	pebbly sand
349	BG			20:27	66°58.19	11°07.34	312	reef top
350	BG			20:52	66°58.15	11°07.31	317	pebbly sand
351	BG			21:18	66°58.08	11°07.44	319	pebbly sand
352	BG			21:41	66°58.02	11°07.71	317	pebbly sand
353	BG			22:05	66°57.96	11°07.83	317	pebbly sand
354	CTD			22:43	66°58.15	11°07.27	313	2 bottles (313m, 304m)
355-1	MB		17.07.2005	0:29	66°57.58	11°05.95	327	start
				0:54	66°56.68	11°00.63	327	end
355-2	MB			0:58	66°56.80	11°00.49	326	start
				1:23	66°57.69	11°05.86	301	end
355-3	MB			1:27	66°57.82	11°05.71	301	start
				1:52	66°56.93	11°00.31	320	end
355-4	MB			1:56	66°57.06	11°00.17	320	start
				2:29	66°57.93	11°05.61	320	end
355-5	MB			2:35	66°58.05	11°05.48	298	start
				2:49	66°57.18	11°00.01	308	end
355-6	MB			2:52	66°57.29	10°59.88	309	start
				3:18	66°58.13	11°05.39	295	end
355-7	MB			3:30	66°58.63	11°07.73	290	start
				4:17	66°57.41	10°59.73	302	end
355-8	MB			4:23	66°57.53	10°59.59	299	start
				5:01	66°58.74	11°07.68	287	end
355-9	MB			5:18	66°57.85	11°08.76	333	start
				6:01	66°56.54	11°00.81	320	end
356	JAGO			6:50	66°58.41	11°06.66	300	start of dive 902
				10:46	66°58.23	11°06.27	304	end of dive 902
357	GKG			12:08	66°58.23	11°07.63	315	Reef top (38cm recovery)
358	GKG			13:10	66°58.13	11°07.82	314	Reef top (42cm recovery)
359	SL-6m			14:05	66°58.24	11°07.63	315	Reef top (564cm recovery)
360	CTD			14:58	66°58.42	11°06.54	299	4 bottles (3x297m, 286m)
361	MB			15:50	66°56.37	11°01.02	324	start
				16:28	66°56.71	11°09.05	352	end
362	CTD			21:16	67°10.13	09°18.53	479	3 bottles (478m, 467m, 439m)
363	JAGO	Røst Reef	18.07.2005	7:23	67°34.49	09°33.84	365	start of dive 903
				8:55	67°34.62	09°35.34	323	end of dive 903
364-1	MB			10:47	67°35.17	09°36.05	321	start
				11:33	67°33.16	09°45.50	221	end
364-2	MB			11:40	67°33.01	09°44.81	220	start
				12:24	67°35.07	09°35.40	368	end
364-3	MB			12:32	67°34.88	09°34.73	340	start
				12:43	67°34.41	09°36.97	261	end
365	JAGO			13:22	67°34.31	09°39.97	247	start of dive 904
				16:33	67°34.20	09°40.59	242	end of dive 904
366-1	MB			17:58	67°34.89	09°34.99	345	start
				19:35	67°29.15	09°21.31	361	end
366-2	MB			19:58	67°29.01	09°21.97	309	start
				23:09	67°36.65	09°40.05	307	end
366-3	MB			23:20	67°36.88	09°38.99	359	start
			19.07.2005	1:21	67°29.30	09°20.65	461	end
366-4	MB			1:37	67°29.57	09°19.94	459	start
				3:28	67°37.18	09°38.11	393	end
366-5	MB			3:50	67°36.40	09°40.78	283	start
				5:46	67°28.77	09°23.62	280	end
367	BG			8:17	67°31.67	09°29.83	310	coral rubble
368	BG			8:46	67°31.62	09°29.63	325	stiff clay
369	BG			9:15	67°31.74	09°30.14	331	live corals
370	BG			9:58	67°31.23	09°28.59	315	coral rubble
371	BG			10:40	67°31.43	09°28.43	368	pebbly sand
372	BG			11:48	67°30.44	09°25.52	303	live corals
373	CTD			14:44	67°31.51	09°29.40	315	2 bottles (310m, 298m)
374	CTD			15:24	67°31.60	09°29.60	316	2 bottles (315m, 304m)
375	CTD			16:00	67°31.66	09°29.83	308	2 bottles (304m, 292m)
376-1	CTD			16:39	67°31.75	09°30.16	330	2 bottles (319m, 306m)
376-2	CTD			17:12	67°31.77	09°30.21	329	2 bottles (318m, 307m)
377	CTD			17:50	67°31.81	09°30.31	346	2 bottles (331m, 320m)
378	CTD			18:31	67°31.58	09°30.40	271	2 bottles (265m, 254m)
379	CTD			19:07	67°31.65	09°30.16	320	2 bottles (305m, 294m)
380	CTD			19:42	67°31.77	09°29.80	323	2 bottles (322m, 311m)

381	CTD			20:46	67°31.88	09°29.48	338	12 bottles (10 x 336m, 2 x 324m)
382	Echosounder	Sveinsgrunnen Slope	21.07.2005	21:51	69°41.41	16°09.97	198	start
				22:03	69°42.52	16°08.99	561	end
383	CTD			22:44	69°43.01	16°07.48	1040	3 bottles (1039m, 593m, 298m)
384	Echosounder		22.07.2005	0:09	69°43.33	16°20.52	548	start
				0:26	69°42.25	16°22.19	80	end
385-1	MB			1:05	69°42.25	16°22.18	86	start
				1:55	69°41.25	16°10.01	200	end
385-2	MB			2:03	69°41.54	16°09.74	186	start
				2:53	69°42.50	16°21.87	274	end
385-3	MB			3:02	69°42.78	16°21.51	413	start
				3:41	69°41.84	16°09.47	219	end
385-4	MB			3:52	69°42.12	16°09.18	327	start
				4:44	69°43.07	16°21.07	499	end
385-5	MB			4:53	69°43.33	16°20.68	556	start
				5:32	69°42.41	16°08.87	577	end
385-6	MB			6:05	69°41.96	16°16.89	148	start
				6:28	69°42.37	16°22.13	166	end
385-7	MB			6:35	69°42.63	16°21.69	348	start
				6:55	69°42.18	16°15.79	158	end
386	CTD			7:20	69°42.46	16°14.02	188	4 bottles (188m, 175m, 50m,10 m)
387	BG			8:10	69°42.00	16°14.99	163	boulders
388	BG			8:56	69°42.53	16°21.75	289	boulders, bioclastic sand
389	BG			9:23	69°42.52	16°21.02	302	boulders, bioclastic sand
390	BG			9:50	69°42.76	16°18.64	327	boulders, bioclastic sand
391	BG			10:53	69°42.79	16°15.99	282	boulders, bioclastic sand
392	BG			11:34	69°42.72	16°15.07	255	boulders, bioclastic sand
393	CTD			12:54	69°42.69	16°11.45	323	—
394	CTD			13:44	69°42.82	16°09.81	523	—
395	CTD			14:38	69°42.95	16°08.60	718	—
396	CTD	Fugløybanken Trough		20:16	70°07.74	18°07.98	383	2 bottles (383m, 371m)
397-1	MB			21:02	70°08.24	17°53.09	282	start
				21:53	70°07.16	18°07.07	369	end
397-2	MB			21:59	70°07.39	18°07.22	365	start
				22:47	70°08.48	17°53.15	291	end
397-3	MB			22:52	70°08.74	17°53.39	328	start
				23:37	70°07.69	18°07.37	374	end
397-4	MB			23:43	70°07.97	18°07.46	368	start
			23.07.2005	0:15	70°07.97	18°07.46	343	end
397-5	MB			1:10	70°09.27	17°53.63	329	start
				2:01	70°08.27	18°07.34	355	end
397-6	MB			2:23	70°06.93	18°06.95	344	start
				3:08	70°08.00	17°53.06	252	end
397-7	MB			3:26	70°07.79	17°52.92	174	start
				4:34	70°06.73	18°06.83	345	end
398-1	BG			5:09	70°07.47	18°04.66	283	failed
398-2	BG			5:39	70°07.42	18°04.61	301	boulder
399	BG			6:19	70°07.83	18°04.68	288	lag-deposit
400	BG			7:39	70°08.53	18°04.21	276	pebbly sand
401	BG			8:25	70°08.43	18°05.42	302	pebbles, silty sand
402	BG			8:51	70°08.36	18°06.48	337	pebbles, silty sand
403	BG			9:19	70°07.87	18°07.11	360	pebbles, silty sand
404	BG			9:59	70°06.85	18°02.23	236	Bryomol sand
405	BG			10:45	70°07.13	18°00.16	228	pebbles
406	BG			11:38	70°07.51	17°57.51	157	Bryomol sand
407-1	BG			12:06	70°07.84	17°54.96	262	Bryomol sand
407-2	BG			12:34	70°07.84	17°54.94	260	Bryomol sand
408	BG			13:23	70°08.75	17°56.78	352	clayey silty sand
409-1	MB			14:40	70°09.55	17°53.95	324	start
				15:54	70°08.54	18°07.81	337	end
409-2	MB			16:00	70°08.77	18°07.92	280	start
				16:49	70°09.80	17°54.20	318	end
410	CTD	Stjernsund	25.07.2005	3:15	70°14.93	22°35.47	467	2 bottles (464m, 453m)
411-1	MB			3:53	70°15.60	22°32.92	392	start
				4:25	70°17.28	22°24.42	366	end
411-2	MB			4:34	70°17.11	22°24.03	398	start
				5:05	70°15.44	22°32.53	466	end
411-3	MB			5:13	70°15.27	22°32.13	470	start
				5:55	70°16.93	22°23.65	402	end
411-4	MB			6:03	70°16.77	22°23.22	405	start
				6:41	70°15.09	22°31.76	469	end
412	JAGO			8:18	70°15.65	22°29.40	283	start of dive 905
				11:08	70°15.95	22°29.59	212	end of dive 905
413	BG			12:50	70°15.83	22°28.84	248	coral rubble
414	BG			13:01	70°15.86	22°28.59	245	coral rubble
415	BG			13:17	70°15.99	22°28.35	236	coral rubble
416	BG			13:28	70°16.13	22°28.54	208	live corals
417	JAGO			14:10	70°16.13	22°28.54	210	start of dive 906
				16:20	70°15.34	22°30.50	366	end of dive 906
418	CTD			17:33	70°15.51	22°31.37	420	2 bottles (411m, 401m)
419	CTD			18:30	70°15.74	22°30.46	369	2bottles (363m, 350m)
420	CTD			19:06	70°16.00	22°29.11	253	3 bottles (248m, 248m, 237m)
421	CTD			19:42	70°16.01	22°28.46	210	2 bottles (213m, 210m)
422	CTD			20:17	70°16.19	22°28.15	298	2 bottles (299m, 288m)
423	CTD			20:55	70°16.36	22°27.07	362	2 bottles (359m, 349m)
424	CTD			21:40	70°16.65	22°25.40	388	2 bottles (383m, 374m)
410-2	CTD			22:47	70°14.86	22°34.98	467	2 botttles (463m, 455m)
425-1	MB			23:56	70°17.46	22°24.86	109	start
			26.07.2005	0:31	70°15.79	22°33.30	190	end

425-2	MB			1:12	70°17.03	22°23.80	401	start
				1:23	70°16.58	22°22.85	407	end
425-3	MB			2:02	70°14.90	22°31.42	326	start
				2:06	70°14.79	22°31.21	322	end
425-4	MB			2:47	70°16.47	22°22.58	355	start
				2:53	70°16.28	22°22.25	161	end
425-6	MB			3:05	70°15.51	22°26.20	227	start
				3:29	70°15.49	22°32.63	467	end
425-7	MB			3:43	70°14.58	22°37.69	468	start
				3:50	70.14.48	22°37.53	469	end
425-8	MB			4:07	70°15.40	22°32.40	444	start
				4:25	70°15.15	22°31.91	472	end
425-9	MB			4:40	70°14.23	22°37.17	470	start
				4:47	70°14.00	22°36.77	459	end
426	BG			6:29	70°15.88	22°28.77	257	coral rubble
427	BG			7:05	70°16.29	22°28.75	225	coral rubble
428	BG			7:39	70°15.82	22°27.80	264	failed
429	JAGO			8:09	70°16.04	22°28.62	212	start of dive 907
				13:21	70°15.82	22°28.43	299	end of dive 907
430-1	GKG			14:45	70°16.50	22°23.07	407	failed
430-2	GKG			15:11	70°16.50	22°23.07	407	46cm recovery
430-3	SL-6m			15:52	70°16.50	22°23.10	407	450cm recovery
431	CTD	Sotbakken		22:02	70°37.91	20°03.57	256	
432-1	MB			22:52	70°39.89	20°11.01	194	start
				23:37	70°38.79	19°56.35	205	end
432-2	MB			23:44	70°38.58	19°56.46	209	start
			27.07.2005	0:33	70°39.66	20°11.17	201	end
432-3	MB			0:38	70°39.42	20°11.34	198	start
				1:21	70°38.34	19°56.57	207	end
432-3	MB			1:25	70°38.11	19°56.68	243	start
				2:08	70°39.17	20°11.50	206	end
433	JAGO	Stjernsundet		10:15	70°15.99	22°27.63	365	start of dive 908
				13:55	70°15.43	22°29.14	277	end of dive 908
434-1	GKG			14:49	70°15.02	22°32.81	472	no recovery
434-2	SL-6m			15:36	70°14.99	22°32.81	472	no recovery
435	CTD			16:54	70°15.76	22°30.64	375	only casting
436	CTD			17:41	70°16.38	22°27.24	363	only casting
437	CTD			18:33	70°15.75	22°30.50	374	only casting
438	CTD			19:08	70°16.39	22°27.20	362	only casting
439	CTD			19:53	70°15.74	22°30.49	372	only casting
440	CTD			20:29	70°16.41	22°27.21	361	only casting
441	CTD			21:05	70°15.73	22°30.47	367	only casting
442	CTD			21:42	70°16.39	22°27.23	361	only casting
443	CTD			22:18	70°15.74	22°30.59	371	only casting
444	CTD			22:57	70°16.39	22°27.18	361	only casting
445	CTD			23:42	70°15.73	22°30.49	366	only casting
446	CTD		28.07.2005	0:19	70°16.37	22°27.20	360	only casting
447	CTD			1:02	70°15.70	22°30.52	368	only casting
448	CTD			1:45	70°16.40	22°27.19	361	only casting
449	CTD			2:34	70°15.71	22°30.50	370	only casting
450	CTD			3:27	70°16.42	22°27.21	362	only casting
451	CTD			4:03	70°15.64	22°30.81	369	only casting
452	CTD			4:40	70°16.37	22°27.31	361	only casting
453	CTD			5:15	70°15.83	22°30.73	378	only casting
454	CTD			5:53	70°16.37	22°27.20	372	only casting
455	GKG			6:36	70°16.13	22°29.46	270	coral rubble
456-1	GKG			7:16	70°16.24	22°28.61	236	Gorgonian coral
456-2	GKG			7:39	70°16.25	22°28.57	249	coral rubble
457	SL-3m			8:20	70°16.24	22°28.63	240	Recovery: 300cm
458	SL-6m			8:51	70°16.13	22°29.44	272	no recovery
459	SL-6m			9:18	70°16.25	22°28.60	258	Recovery: 300cm
460	JAGO			10:53	70°15.99	22°27.73	330	start of dive 909
				14:51	70°15.72	22°27.12	205	end of dive 909
461-1	MB	Sotbakken		23:55	70°38.94	20°11.66	201	start
			29.07.2005	0:50	70°37.86	19°56.73	238	end
461-2	MB			0:56	70°37.62	19°56.84	230	start
				1:50	70°38.70	20°11.83	201	end
461-3	MB			1:56	70°38.49	20°12.04	195	start
				2:53	70°37.40	19°57.00	211	end
461-4	MB			2:59	70°37.17	19°57.11	219	start
				3:50	70°38.25	20°12.21	201	end
461-5	MB			3:57	70°38.04	20°12.43	215	start
				5:04	70°36.90	19°57.22	194	end
461-6	MB			5:11	70°36.66	19°57.22	202	start
				5:59	70°36.68	20°12.21	164	end
461-7	MB			6:06	70°36.90	20°12.21	165	start
				6:59	70°36.92	19°57.22	195	end
462	BG			7:55	70°39.07	20°06.37	193	sand
463	BG			8:48	70°38.98	20°03.76	193	sand
464	BG			9:34	70°38.65	19°57.49	209	sand
465	BG			10:32	70°38.15	20°08.70	229	boulders
466	BG			11:24	70°37.98	20°06.63	267	boulders
467	BG			12:12	70°38.12	20°06.28	237	boulders
468	JAGO			13:03	70°37.42	20°07.55	264	start of dive 910
				16:10	70°37.98	20°07.38	251	end of dive 910
469-1	MB			18:30	70°37.13	20°12.21	221	start
				19:14	70°37.13	20°00.05	221	end
469-2	MB			19:32	70°37.33	20°03.54	222	start
				20:03	70°37.39	20°12.21	191	end
469-3	MB			20:10	70°37.62	20°12.26	195	start
				20:28	70°37.62	20°08.07	241	end
469-4	MB			20:47	70°37.84	20°11.50	220	start
				20:50	70°37.86	20°12.32	203	end
470	SL-6m	Stjernsund	30.07.2005	6:21	70°16.39	22°25.81	386	Recovery: 550cm
471	SL-6m			7:00	70°15.85	22°28.23	226	Recovery: 210cm
472	SL-6m			7:38	70°15.68	20°28.92	262	Recovery: 600cm
473	SL-6m			8:12	70°15.49	20°30.22	361	Recovery: 110cm
474	JAGO			12:07	70°15.84	22°27.32	305	start of dive 911
				16:20	70°15.61	22°27.65	206	end of dive 911
475	CTD			17:24	70°15.55	22°27.57	212	only casting
476	CTD			17:57	70°16.06	22°28.39	216	only casting

477	CTD			18:30	70°16.42	22°28.97	264	only casting
478	CTD			19:00	70°15.72	22°27.84	210	only casting
479	CTD			19:31	70°16.26	22°28.66	237	only casting
480	CTD			20:16	70°15.88	22°28.24	231	only casting
481-1	MB			21:00	70°15.79	22°33.30	61	start
				22:03	70°13.99	22°49.99	477	end
481-2	MB			22:10	70°13.68	22°49.82	479	start
				23:20	70°13.62	22°32.90	418	end
481-3	MB			23:26	70°15.44	22°32.57	464	start
			31.07.2005	0:34	70°13.35	22°49.88	477	end
481-4	MB			0:41	70°13.02	22°49.91	463	start
				1:57	70°15.36	22°32.31	460	end
481-5	MB			2:01	70°15.21	22°32.01	473	start
				2:50	70°12.68	22°49.82	311	end
481-6	MB			2:54	70°12.56	22°49.79	120	start
				3:50	70°14.32	22°36.67	469	end
481-7	MB			3:58	70°14.11	22°36.33	464	start
				4:18	70°13.28	22°43.49	49	end
481-8	MB			4:24	70°13.13	22°43.32	228	start
				5:20	70°14.84	22°30.95	246	end
482-1	GKG			7:39	70°13.86	22°47.78	478	
482-2	SL-6m			8:24	70°13.85	22°47.63	479	Recovery: 600cm
483	SL-6m			9:50	70°15.80	22°26.98	358	empty
484	JAGO			12:14	70°15.89	22°27.61	319	start of dive 912
				16:38	70°15.63	22°27.73	305	end of dive 912
485	JAGO		01.08.2005	8:30	70°13.51	22°48.67	486	start of dive 913
				9:57	70°13:42	22°48.56	483	end of dive 913
486	JAGO			12:46	70°16.12	22°28.51	220	start of dive 914
				15:37	70°16.31	22°28.22	255	end of dive 914